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Evaluation of Clinical Criteria for Performing Brain CT-Scan in Patients with Mild Traumatic Brain Injury; A New Diagnostic Probe

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ABSTRACT

Objective: To investigate the risk factors that can be proper indications for performing brain computerized tomography (CT)-scan in patients with mild and moderate traumatic brain injury (TBI) in order to avoid unnecessary exposure to radiation, saving on costs as well as time wasted in emergency wards.
Methods: Data of patients with mild traumatic brain injury (TBI) referring to Emergency Department with age ≥2 years and primary GCS of 13-15 were examined including focal neurological deficit, anisocoria, skull fracture, multiple trauma, superior injury of clavicle, decreased consciousness, and amnesia. Brain CT-scan was performed in all the patients. Kappa Coefficient was used to determine the ratio of agreement of the CT indications (+ and -) and multiple logistic regression to determine the relative odds of positive CTs.
Results: Overall we included 610 patients. One-hundred and one patients (16.5%) had positive and 509 (83.5%) had negative CT findings. Of positive CTs, the highest percentage was dedicated to high-energy mechanism of trauma. High-energy trauma mechanism (OR=1.056, 95% CI, OR, 1.03-1.04, p<0.001), superior injury of clavicle (OR=1.07, 95% CI, OR, 1.03-1.1, p<0.001) and moderate to severe headache (OR=1.04, 95% CI, OR, 1.02-1.05, p<0.001) were positive predictors of CT findings. The combined mean of positive symptoms equaled 0.290.64± in negative CTs, but 5.132.4± in positive CTs, showing a significant difference. (p<0.001)
Conclusion: Abnormal positive brain CT in victims with mild TBI is predictable if one or several risk factors are taken into account such as moderate to severe headache, decreased consciousness, skull fracture, high-energy trauma mechanism, superior injury of clavicle and GCS of 13-14. The more the symptoms, the more likely the positive CT results would be.

Keywords: Computerized tomography (CT)-scan; Traumatic brain injury (TBI); Criteria; Clinical; Brain.

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Introduction

Traumatic brain injury (TBI) is the major leading cause of brain parenchyma damage. Severe brain damage is an intracranial injury which is more common than moderate and mild TBI, however, even the risk of brain damage in mild cases should not be taken for granted. Therefore, in many cases, CT scan is performed to assess the brain damage which increases the *risks* of *radiation* exposure and in a broader sense leads to higher financial burden on the community [1]. Craniocerebral injury is a common cause of hospitalization following trauma, with a long-term morbidity and a striking number of mortalities.

According to the American Congress of Rehabilitation Medicine (ACRM) and World Health Organization (WHO), mild head injury is characterized by GCS=13-15 which occurs following a blunt trauma or a decreasing-increasing force to the brain. This includes dizziness, loss of consciousness (LOC) within 30 minutes or less, post-traumatic amnesia less than 24 hours, or other transient neurological problems such as focal seizures and intracerebral lesions [2]. Other symptoms including headache, lightheadedness, irritability, vomiting, blurred vision, fatigue, and poor concentration have also been reported [2, 3]. Over time, more lethal complications and life-threatening conditions following mild head injury may be observed. In 6-21% of these patients, intracerebral lesions are reported, 0.4% to 1% of whom require neurosurgical interventions [4-8], though the amount of these interventions is low for this group and long-term complications are yet to know [9, 10]. The term "complicated mild head injury" has been attributed to this group of patients and employed by some authors but it is still controversial [4, 11]. The number of patients with head injury in the United States is estimated to be about 800,000 to 2 million per year, of whom 80% have mild injuries [12]. In fact, developing applicable clinical guidelines reduces the amount of inessential imaging and avoids the unnecessary exposure to radiation, saving on costs as well as time wasted in emergency wards [4, 11-16]. The most reliable set of rules for mild head injury is the Canadian CT Head Rule (CCHR), which was presented in 2001 by Stiell *et.al*. According to this guideline, patients are classified into two high- and moderate- risk. High-risk criteria include GCS below 15 (2 hrs after injury), suspicious open or depressed fractures in the skull, symptoms of skull base fracture (hemotympanum, raccoon eye, cerebrospinal fluid rhinorrhea and otorrhea, Battle's sign), vomiting at least two times, and age over 65. The moderate-risk criteria include GCS=15, short-term LOC, amnesia after trauma, vomiting, headache, toxicity. Moreover, low-risk criteria are characterized as being asymptomatic at the time, no other injuries and focal neurological deficit and change in LOC, normal pupils, normal memory, GCS=15, detailed history, mild injury mechanism, injury in less than 24 hrs, no headache or mild headache, no vomiting and no high-risk factors [17]. Although increasing referrals to hospitals and radiology departments complicates the treatment and imaging procedures, in order to reduce the economic burden of the health system and the exposure to radiation and to best organize the priorities in this condition, certain guidelines should be set with high sensitivity to help physicians distinguish the patients who need emergency CT scans. According to previous reports, 10% decrease in number of scans due to mild brain injury can reduce the expenditure of US health system for about 20 million dollars [18]. Thus, this study aimed at examining the pre-determined criteria and its diagnostic value considering the CT findings so as to provide new, comprehensive, and precise criteria for identifying patients with mild-to-severe brain injury who may need CT imaging.

Materials and Methods

Patients

This is a diagnostic study which was conducted prospectively on all the patients older than 2 years (regardless of sex) with blunt TBI and GCS ≥13, who were referred to emergency department of Poursina Hospital in Rasht (North of Iran) from March 2016 to March 2018. All of them needed brain CT scan imaging according to risk classification criteria which was ordered and performed within 24 hours after occurrence of blunt trauma.

Study Protocol

The study sample size was calculated 598, according to the predictive criteria based on positive CT results of the study by Sharifi Al-Husseini *et al*., [10] with 95% confidence and 90% strength of the test, using low sampling formula. The patients were first examined by the Emergency Medical clinicians and their demographic information and determined criteria were recorded including focal neurological deficit, anisocoria, skull fracture detected during the clinical examination, multiple trauma, painful severe injuries, external symptoms of superior injury of clavicle, primary GCS=13-15, LOC, amnesia or dizziness after trauma, progressive or non-progressive headache, vomiting, post-trauma seizure, history of bleeding or anticoagulant disorder, recent ingestion of toxic substances (e.g. alcoholic drinks), and trauma mechanism (high-energy: vehicle-pedestrian collision, getting thrown out of the vehicle, and falling from height more than 3 feet or five stairs with low energy) (Figure 1). The severity of the headache was determined by the numerical scale of the pain. Based on this score, 0 to 4 was considered mild headache, 4 to 7 moderate headache and more than 7 was categorized as severe headache [19].

Exclusion Criteria

Hemodynamic instability, other complications requiring special care, opium addiction, and not giving consent to participate in the study were the exclusion criteria of the study. The questionnaire containing clinical information of the patient was completed before performing CT. The results of the

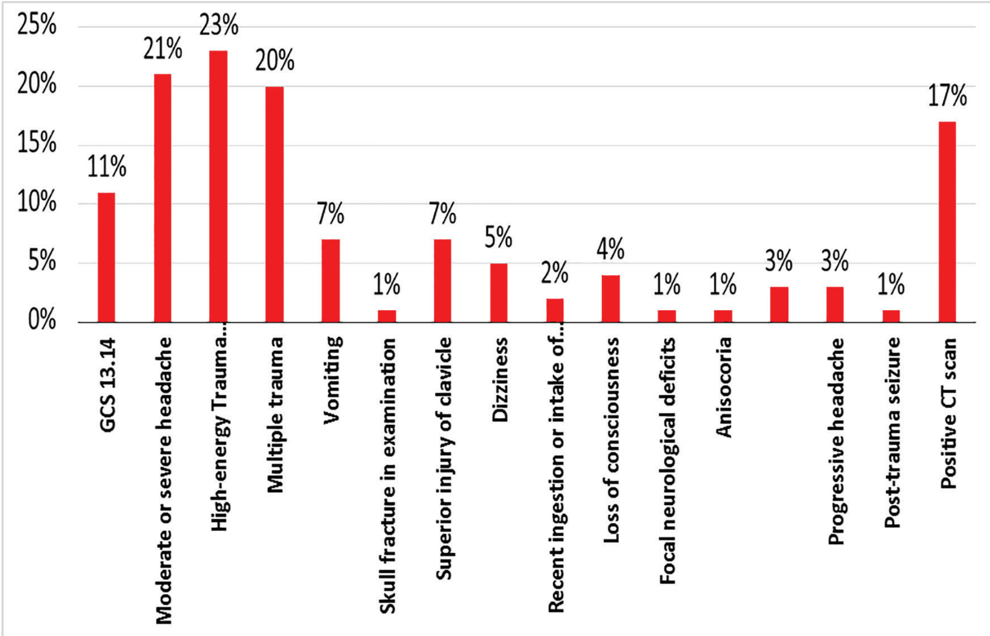

Fig. 1. Percent of positive symptoms of patients during examination in CT scan in cases under study in Emergency Department of Poursina Hospital, Rasht.

brain imaging were interpreted by the radiography attends, and trauma-related lesions including bone fractures, epidural hematoma, subdural hematoma, subarachnoid hemorrhage, pneumocephalus and contusion were recorded. The number of positive CTs was evaluated considering each risk factor (Figure 2).

Statistical Analysis

The sensitivity and specificity of both the positive and negative predictors of each risk factor were specified. After collecting the data, they were analyzed using SPSS software (Version 21). The Kappa agreement coefficient (+ and -) was used to determine the agreement of the CT ratio. To determine the diagnostic value and the accuracy of these criteria for predicting positive CTs, LR +, LR-, PPV, NPV, sensitivity, specificity, and accuracy were used. The logistic regression model was used to determine the odds ratio of the positive CT predictors in multiple analysis. The significance level of the study was considered P less than 5% (Table 1).

Results

Of all 610 patients, 101 (16.6%) had positive CT results and 509 had negative results. Their age ranged from the minimum of 2 to maximum of 95 years old (Mean±SD=41.6±20.1). Most of the patients were male (n=397, 65.1%) and the rest of them were female (n=213, 34.9%). According to Table 2, among all of the positive symptoms of the patient during examination by the emergency staff, the highest percentage of traumas dedicated to the

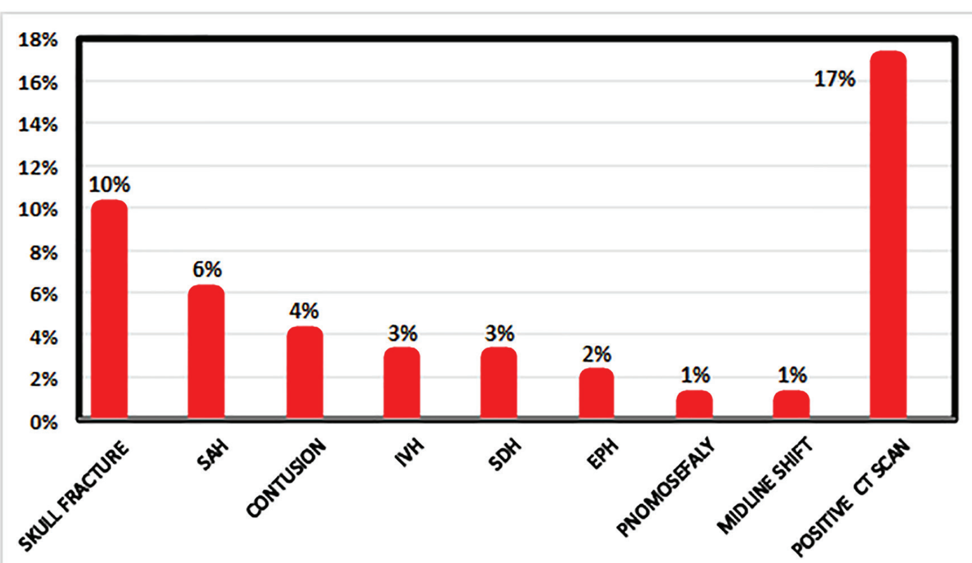

Fig. 2. Percent of positive CT findings in cases under study in Emergency Department of Poursina Hospital, Rasht.

Table 1. Frequencies of associated characteristics in positive and negative CT scan

Variables	Positive CT scan				
	No		Yes		
	Count	%	Count	%	*p*
GCS=13-14	6	1.2%	60	59.4%	<0.001
High-energy mechanism	43	8.4%	99	98.0%	<0.001
Moderate to severe headache	34	6.7%	94	93.1%	<0.001
Multiple trauma	57	11.2%	64	63.4%	<0.001
Vomiting	7	1.4%	34	33.7%	<0.001
Skull fracture during examination	0	0.0%	9	8.9%	<0.001
Superior injury of clavicle	1	0.2%	41	40.6%	<0.001
Dizziness after trauma	1	0.2%	32	31.7%	<0.001
Alcohol intoxication	0	0.0%	15	14.9%	<0.001
LOC	0	0.0%	26	25.7%	<0.001
Focal neurological deficit	0	0.0%	7	6.9%	<0.001
Anisocoria	0	0.0%	7	6.9%	<0.001
History of bleeding or anticoagulant disorder	0	0.0%	17	16.8%	<0.001
Progressive headache	0	0.0%	16	15.8%	<0.001
Post-trauma seizure	0	0.0%	6	5.9%	<0.001

Table 2. The percentage of positive and negative symptoms in the emergency department of Poursina Hospital, Rasht according to CT findings

		Positive CT SCAN								
		No			Yes			Total		
		No	Yes	Total	No	Yes	Total	No	Yes	Total
GCS:13 or 14	n	503	6	509	41	60	101	544	66	610
	Percent	98.80%	1.20%	100.00%	40.60%	59.40%	100.00%	89.20%	10.80%	100.00%
High-energy trauma mechanism	n	466	43	509	2	99	101	468	142	610
	Percent	91.60%	8.40%	100.00%	2.00%	98.00%	100.00%	76.70%	23.30%	100.00%
Moderate to severe headache	n	475	34	509	7	94	101	482	128	610
	Percent	93.30%	6.70%	100.00%	6.90%	93.10%	100.00%	79.00%	21.00%	100.00%
Multiple trauma	n	452	57	509	37	64	101	489	121	610
	Percent	88.80%	11.20%	100.00%	36.60%	63.40%	100.00%	80.20%	19.80%	100.00%
Vomiting	n	502	7	509	67	34	101	569	41	610
	Percent	98.60%	1.40%	100.00%	66.30%	33.70%	100.00%	93.30%	6.70%	100.00%
Skull fracture during examination	n	509	0	509	92	9	101	601	9	610
	Percent	100.00%	0.00%	100.00%	91.10%	8.90%	100.00%	98.50%	1.50%	100.00%
Superior injury of clavicle	n	508	1	509	60	41	101	568	42	610
	Percent	99.80%	0.20%	100.00%	59.40%	40.60%	100.00%	93.10%	6.90%	100.00%
Dizziness after trauma	n	508	1	509	69	32	101	577	33	610
	Percent	99.80%	0.20%	100.00%	68.30%	31.70%	100.00%	94.60%	5.40%	100.00%
Alcohol intoxication	n	509	0	509	86	15	101	595	15	610
	Percent	100.00%	0.00%	100.00%	85.10%	14.90%	100.00%	97.50%	2.50%	100.00%
LOC	n	509	0	509	75	26	101	584	26	610
	Percent	100.00%	0.00%	100.00%	74.30%	25.70%	100.00%	95.70%	4.30%	100.00%
Focal neurologic deficit	n	509	0	509	94	7	101	603	7	610
	Percent	100.00%	0.00%	100.00%	93.10%	6.90%	100.00%	98.90%	1.10%	100.00%
Anisocoria	n	509	0	509	94	7	101	603	7	610
	Percent	100.00%	0.00%	100.00%	93.10%	6.90%	100.00%	98.90%	1.10%	100.00%
Bleeding disorder	n	509	0	509	84	17	101	593	17	610
	Percent	100.00%	0.00%	100.00%	83.20%	16.80%	100.00%	97.20%	2.80%	100.00%
Progressive headache	n	509	0	509	85	16	101	594	16	610
	Percent	100.00%	0.00%	100.00%	84.20%	15.80%	100.00%	97.40%	2.60%	100.00%
Seizure after trauma	n	509	0	509	95	6	101	604	6	610
	Percent	100.00%	0.00%	100.00%	94.10%	5.90%	100.00%	99.00%	1.00%	100.00%

high-energy trauma mechanism (23.3%) followed by moderate to severe headache (21%), multiple trauma (19.8%) and GCS: 13 or 14 (10.8%). Table 3 summarizes the results of the symptoms of patients in emergency medicine, the results of CT scan, and the indicators of each of the symptoms. Based on the data exhibited, the highest percentage of accuracy belonged to severe to moderate headache (93.3%), high-energy trauma mechanism (92.6%), GCS 13, 14 (92.6%) and superior injury of clavicle (90%), respectively. Other symptoms had a lower percentage.

Table 4 shows that the combined mean of positive symptoms in the negative CT scan was 0.29±0.64, with a minimum of 0 and a maximum of 5, but these values in positive CT scans were 2.4±2.4 with a minimum of one and a maximum 13 which were statistically significant. Table 5 shows that based on the logistic regression model, among the symptoms examined by the emergency medical staff except for two symptoms including skull fracture during examination and LOC which were positive in all CTs, GCS=13 or 14 with a relative chance of 1.02, moderate to severe headache with a relative chance of 1.04, high-energy trauma mechanism with a relative chance of 1.06 and the superior injury of clavicle with a relative chance of 1.07 were positive predictors of CT results. It should be noted that among these symptoms, GCS=13, 14 remained in the final model, though it was not statistically significant.

Abnormal positive brain CT in victims with mild brain trauma is predictable considering one or several risk factors such as moderate to severe headache, decreased consciousness, skull fracture, high-energy trauma mechanism, superior injury of clavicle and GCS=13-14. It is concluded that when the number of the symptoms is high, the positive CT results would be more. In our study, all variables were statistically significant in terms of p-value but in logistic regression analysis, only 3 risk factors including high-energy trauma mechanism, the superior injury of clavicle, and moderate to severe headache were significant in terms of odds ratio and p-value which were strongly indicative of positive CT in patients with mild head trauma. These 3 factors

Table 3. Diagnostic indicators of patient symptoms in emergency medicine to predict CT results

			Positive CT			Statistical Indices	Amount
			No	Yes	Total		
GCS: 13, 14	No	n	503	41	544	Sen, Spe	59.4 /98.8
		Percent	82.50%	6.70%	89.20%	PPV,NPV	90.9 /92.5
	Yes	n	6	60	66	LR+,LR-	50.4 /0.41
		Percent	1.00%	9.80%	10.80%	Accuracy	92.60%
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		
High-energy trauma mechanism	No	n	466	2	468	Sen, Spe	98.02 /91.55
		Percent	76.40%	0.30%	76.70%	PPV,NPV	69.72 /99/57
	Yes	n	43	99	142	LR+,LR-	11.6 /0.02
		Percent	7.00%	16.20%	23.30%	Accuracy	92.60%
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		
Moderate to severe headache	No	n	475	7	482	Sen, Spe	93.07 /93.32
		Percent	77.90%	1.10%	79.00%	PPV,NPV	73.44 /98/55
	Yes	n	34	94	128	LR+,LR-	13/93 /0.07
		Percent	5.60%	15.40%	21.00%	Accuracy	93.30%
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		
Multiple trauma	No	n	452	37	489	Sen, Spe	63.37 /88/80
		Percent	74.10%	6.10%	80.20%	PPV,NPV	52.89 /9243
	Yes	n	57	64	121	LR+,LR-	5.66 /0.41
		Percent	9.30%	10.50%	19.80%	Accuracy	84.60%
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		
Vomiting	No	n	502	67	569	Sen, Spe	33.66 /98.62
		Percent	82.30%	11.00%	93.30%	PPV,NPV	82.93 /88.22
	Yes	n	7	34	41	LR+,LR-	24.48 /0.67
		Percent	1.10%	5.60%	6.70%	Accuracy	87.90%
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		

Skull fracture during examination	No	n	509	92	601	Sen, Spe	8.91/100
		Percent	83.40%	15.10%	98.50%	PPV,NPV	100/84.69
	Yes	n	0	9	9	LR+,LR-	0 /0.91
		Percent	0.00%	1.50%	1.50%	Accuracy	84.90%
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		
Superior injury of clavicle	No	n	508	60	568	Sen, Spe	40.59/99.80
		Percent	83.30%	9.80%	93.10%	PPV,NPV	97.62/8944
	Yes	n	1	41	42	LR+,LR-	206.6/0.6
		Percent	0.20%	6.70%	6.90%	Accuracy	90%
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		
Dizziness after trauma	No	n	508	69	577	Sen, Spe	31.68/99.8
		Percent	83.30%	11.30%	94.60%	PPV,NPV	96.97/88.04
	Yes	n	1	32	33	LR+,LR-	167.27/0.68
		Percent	0.20%	5.20%	5.40%	Accuracy	88.50%
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		
Alcohol intoxication	No	n	509	86	595	Sen, Spe	21.3 /100
		Percent	83.40%	14.10%	97.50%	PPV,NPV	100/ 90.9
	Yes	n	0	15	15	LR+,LR-	0 /0.79
		Percent	0.00%	2.50%	2.50%	Accuracy	85/9%
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		
LOC	No	n	509	75	584	Sen, Spe	25.74/99.28
		Percent	83.40%	12.30%	95.70%	PPV,NPV	100/87.6
	Yes	n	0	26	26	LR+,LR-	0 / 0.74
		Percent	0.00%	4.30%	4.30%	Accuracy	87/7%
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		
Focal neurologic deficit	No	n	509	94	603	Sen, Spe	6/93 /100
		Percent	83.40%	15.40%	98.90%	PPV,NPV	100/84.41
	Yes	n	0	7	7	LR+,LR-	0 /0.93
		Percent	0.00%	1.10%	1.10%	Accuracy	84.5
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		
Anisocoria	No	n	509	94	603	Sen, Spe	6/93 /100
		Percent	83.40%	15.40%	98.90%	PPV,NPV	100/84.41
	Yes	n	0	7	7	LR+,LR-	0 /0.93
		Percent	0.00%	1.10%	1.10%	Accuracy	84.5
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		
Bleeding disorder	No	n	509	84	593	Sen, Spe	16.82/100
		Percent	83.40%	13.80%	97.20%	PPV,NPV	100/85.8
	Yes	n	0	17	17	LR+,LR-	0 /0.83
		Percent	0.00%	2.80%	2.80%	Accuracy	86.20%
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		
Progressive headache	No	n	509	85	594	Sen, Spe	15.84/100
		Percent	83.40%	13.90%	97.40%	PPV,NPV	100/85.69
	Yes	n	0	16	16	LR+,LR-	0 /0.84
		Percent	0.00%	2.60%	2.60%	Accuracy	86%
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		
Seizure after trauma	No	n	509	95	604	Sen, Spe	5.94/ 100
		Percent	83.40%	15.60%	99.00%	PPV,NPV	100/84/27
	Yes	n	0	6	6	LR+,LR-	0/0/94
		Percent	0.00%	1.00%	1.00%	Accuracy	84/4%
	Total	n	509	101	610		
		Percent	83.40%	16.60%	100.00%		

Table 4. Comparison of the number of positive symptoms in terms of CT results

		Positive CT SCAN		*p*
		No	**Yes**	
Number of positive symptoms	Mean	0.29	5.13	0.0001
	Standard Deviation	0.64	2.37	
	Minimum	0	1	
	Maximum	5	13	
	95.0% Lower CL for Mean	0.24	4.66	
	95.0% Upper CL for Mean	0.35	5.6	

Table 5. Regression coefficients and relative odds of clinical symptoms of patients in the emergency department as predictors of CT results

		B	S.E.	Sig.	Relative chance	95% CI for OR	
					(odds ratio)	**Lower**	**Upper**
Final model	GCS[a]: 13,14	0.019	0.012	0.107	1.019	0.996	1.042
	Moderate to severe headache	0.036	0.006	0	1.036	1.024	1.049
	High-energy trauma mechanism	0.054	0.011	0	1.056	1.034	1.078
	Superior injury of clavicle	0.064	0.02	0.001	1.066	1.025	1.109
	Constant	-7.305	1.093	0	0.001		

[a] GCS: 13.14; a. Variable(s) entered on step 1. focal neurological deficit, anisocoria, skull fracture, multiple trauma, severe headache, superior injury of clavicle, amnesia/dizziness, progressive headache, vomiting, seizure, bleeding or anticoagulant disorders, recent intake of toxic substances, and high-energy trauma mechanism

Discussion

Among the risk factors of the present study, except for two symptoms including skull fracture during examination and loss of consciousness, which were positive in all CTs, GCS=13 or 14 with a relative chance of 1.02, moderate to severe headache with a relative chance of 1.04, high-energy trauma mechanism with relative odds of 1.06 and the superior injury of clavicle with a relative chance of 1.07 were positive predictors of CT scans. Among all these symptoms, GCS=13,14, though remained in the final model, was not statistically significant.

Al-Husseini *et al.*, [10] in their study concluded that abnormal CT scan of the brain after trauma and mild injury were predictable by risk factors such as headache, vomiting, loss of consciousness, amnesia and alcohol intoxication which meant the presence of a high-risk injury [10, 20] Our study also found that moderate to severe headache were positive predictors of CT findings. Several studies have confirmed LOC as a risk factor for abnormal CT results in mild head trauma [10, 15, 21, 22] which is compatible with our results. Mousavi and Hashemian (2014) examined the role of brain CT scan in diagnosing patients with mild head trauma at a trauma center, concluding that the CCHR criteria were more accurate and reliable than others and clinicians could reliably detect patients with mild head injuries who needed immediate brain scan [23, 24]. Abdullah Zadegan and Rahimi-Movaghar in a review article evaluated the indications of brain CT scan after mild head injury and examined the different items used in the criteria. They finally concluded that the CCHR was the most reliable indicator with a good sensitivity. However, they believed that without considering the history of patients (drug poisoning, alcohol, and coagulation disorder), some may remain undiagnosed [1].

In 2014, Cemil Kavalci and his colleagues in Turkey conducted a study to compare the CCHR and NOC methods in patients with mild TBI and realized that both methods had a high diagnostic sensitivity but the CCHR method had a higher specificity than NOC. They believed that using CCHR could reduce unnecessary imaging and the complications of radiation as well [25]. In all of the above studies, the CCHR indications have been approved which was previously provided by Stiell *et al.* in 2001. According to this guideline, patients were classified into high- and moderate-risk categories. High-risk criteria included GCS below 15 (2 hrs after injury), open or depressed fracture in the skull, symptoms of skull base fracture (hemotympanum, raccoon eye, cerebrospinal fluid rhinorrhea and otorrhea, Battle's sign), vomiting at least two times, and age over 65 years old. Medium-risk criteria were amnesia for more than 30 minutes before trauma (retrograde amnesia) and a high-risk injury mechanism (such as pedestrian-vehicle accident, getting thrown out of vehicle, falling from a height of more than 3 feet or five stairs) [21]. In a study on GCS, decreased consciousness level, fractures detected during examination and high-energy trauma mechanism were considered as indicators of positive CT [4, 11].

Micelle et al. identified clinical criteria for diagnosing patients with mild head injury, not needing CT scan. All positive CT patients had one or more of the criteria (headache, vomiting, age over 60, medication or alcohol intoxication, short-term memory impairment, evidence of physical damage to the Clavicle and seizure). These researchers suggested that in patients with mild brain injury, performing

CT could be limited to patients with these criteria [26]. In our study, moderate to severe headache and high-risk Clavicle injury were highlighted as strong predictors of positive CT results.

However, in a study by Mack and colleagues (2003), headache was expressed as a mild indicator [19] whereas several studies have proposed that headache can be used as a risk factor [10, 21, 27]. In this study, the severity of headache was tested and the results showed that moderate to severe headache could be selected as an important risk factor, while mild headache was not a good predictor. In a study by Sharif al-Husseini and his colleagues (2011), combining two or more risk factors resulted in more positive CT findings [10]. In the present study, the combined mean of positive symptoms in the negative CT scan was 0.29±0.64 with a minimum of 0 and a maximum of 5 but in positive CT scans, this value was 5.2±2.4 with a minimum of one and a maximum of 13 symptoms, which was statistically significant.

Positive abnormal brain CT scan in patients with mild brain trauma can be predicted by considering one or more risk factors such as moderate to severe headache, LOC, fractures detected during emergency examination, high-energy trauma mechanism, superior injury of clavicle and GCS=13,14. In effect, the higher the number of these symptoms, the higher the chance of positive CT results would be. In sum, the results of the present research can be useful in clinical settings on decision-makings for performing brain CT. The unnecessary use of this modality and unnecessary exposure to radiation can be avoided. Besides, much of energy, time, and financial burden on patients and medical center can diminish. Therefore, future studies are recommended to include control groups with two methods. One method can include performing a CT scan on admission considering the positive symptoms obtained in this study combined with other symptoms and the CCHR. The other method can monitor patients with milder symptoms identified in this study such as mild headache and low-energy trauma mechanism and reassess them with a CT scan before discharge to compare the outcomes. Obviously, the related ethical issues and risks of brain damage should not be taken for granted.

In conclusion, abnormal positive brain CT in victims with mild TBI is predictable if one or several risk factors are taken into account such as moderate to severe headache, decreased consciousness, skull fracture, high-energy trauma mechanism, superior injury of clavicle and GCS of 13-14. The more the symptoms, the more likely the positive CT results would be.

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