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Original Article

Risk factors for intracranial injury diagnosed by cranial CT in emergency department patients with mTBI

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Abstract: Objective: To explore the predictors of early intracranial injury inemergency department patients with mild traumatic brain injury (mTBI). Methods: During the period from January 2010 to December 2015, a total of 3142 patients with mTBI who underwent the computed tomographic (CT) examination in our hospital were analyzed retrospectively. Univariate and multivariate logistic regression models were applied to analyze the predictors of early intracranial injury in patients from seven factors (age, gender, history of alcoholism, nausea/vomiting, pupillary size, transient amnesia and skull fracture). Results: Among 3142 mTBI patients who underwent the cranial CT examination, 1076 patients (34.2%) were diagnosed with intracranial injury by CT scanning and 7 patients (0.2%) were required to undergo the further surgical treatment. The remaining 2066 patients (65.8%), however, revealed no obvious intracranial injury. The single factor analysis was employed to find that among 3142 patients with mTBI who underwent the cranial CT examination, there was no significant differences between the gender (P=0.33), history of alcoholism (P=0.24), and amnesia (P=0.13) in predicting the intracranial injury. The multivariate logistic regression analysis further showed that factors including age >65 years (OR: 3.97, 95% CI: 2.13-5.09, P<0.001), nausea/vomiting (OR: 2.31, 95% CI: 1.25-3.64, P<0.001), anisocoria (OR: 2.72, 95% CI: 1.07-3.92, P<0.001) and skull fracture (OR: 4.11, 95% CI: 1.43-8.52, P<0.001) were significantly correlated with intracranial injury. Conclusion: Advanced age, nausea/vomiting, anisocoria and skull fracture can be regarded as the risk factors in predicting the intracranial injury, thereby reminding the clinicians to perform the cranial CT examination for such kind of patients immediately and then observe their conditions carefully.

Keywords: Emergency injury, cranial computed tomography (CT), intracranial injury, predictors

Introduction

Traumatic brain injury (TBI) is caused by direct or indirect impact to the head. The morbidity and mortality of TBI remain very high and extracranial injury is common especially in the clinical emergency surgery [1, 2]. With the development of society, traffic accidents, various work-related injuries or firearm operation accidents, fighting and other accidents can lead to TBI. Therefore, in recent years, the incidence of TBI has shown an obvious rising trend [3]. TBI is a relatively complex and rapidly progressing disease which can easily cause serious consequences (intracranial hemorrhage (ICH), paralysis, or even death). Patients with more severe conditions cannot be able to get reasonable early treatments if their conditions cannot be identified timely, which can lead to serious medical events. Therefore, it's important to recognize the severity of symptoms among patients with TBI to provide them corresponding treatments as early as possible [4, 5].

TBI can be divided into open injury and closed injury according to whether the brain tissues are exposed to the outside world after injury. Open injury is a severe TBI which generally accompanied with obvious symptoms such as ICH, coma and so on. In this case, the medical staff can deal with the disease quickly in line with the conditions of patients. However, the closed injury with lighter damage is difficult to be identified. So the medical staff should make a comprehensive judgment after combining with patients' symptoms and signs. Even so, the clinical misdiagnosis still occurs. Therefore, there is an urgent need to develop conve-

nient and efficient assistant diagnostic methods, such as CT examination and nuclear magnetic resonance (NMR). The imaging examination of the head, including cranial CT examination, can diagnose the intracranial injury as early as possible, playing a vital role in the diagnosis and treatment of TBI patients [5-7]. However, in recent years, the widespread application of CT examination has greatly increased the relevant risk of radiation, especially in patients with mTBI [8, 9]. The majority of patients with mTBI have no need of CT scanning, and the abuse of CT examination can not only waste the medical resources but also increase the spending of patients. Therefore, it is necessary to study the early predictors of intracranial injury in patients with mTBI. This study aims to provide the objective basis for medical staff to timely judge the conditions of patients and then conduct the further treatment while reducing the clinical misdiagnosis rate and effectively decreasing the bias caused by human factors in the medical triage process.

Objects and methods

General information

A retrospective analysis was employed to analyze the clinical data of patients with initially-diagnosed mTBI in the emergency department of our hospital from January 2010 to December 2015. In this study, a total of 13327 patients with mTBI were consulted and 3142 patients were finally included. Among these included patients, there were 2019 males and 1123 females. The patients' ages were from 17 to 84 years old and the average age was 57.7±8.3 years old. All together 1076 patients (34.2%) were diagnosed with intracranial injury after being detected via the multi-detector row spiral computed tomographic (CT) while the other 2066 patients (65.8%) were diagnosed without obvious intracranial injury. Inclusive criteria: the included TBI patients must have definite injury history; the age of patient should ≥16; the Glasgow coma scale (GCS) score should ≥13; the patients must be admitted in our hospital in 24 h after injury and underwent the simple neurological examination and inquiry and experienced the cranial CT examination. Exclusive criteria: comatose patients with severe TBI; patients younger than 16 years old; the GCS score was less than 13; patients with open TBI; patients should be admitted in our hospital more than 24 h after injury and patients with incomplete data. This study was approved by the Hospital Ethics Committee and all the patients had signed the informed consent forms.

Observed indicators

The basic information and inspection results in patients' medical charts were recorded in details, including age, gender, history of alcoholism, pupillary size, whether there was nausea/vomiting, whether there occurred transient amnesia, whether there was accompanied by the skull fracture and whether there showed intracranial injury after cranial CT examination.

Statistical methods

Statistical analysis was performed by using the SPSS17.0 statistical software. All the measurement data were presented as mean ± standard deviation (mean ± SD). And the enumeration data were expressed as percentage (%). Besides, the chi-square test was employed for the single factor analysis and the logistic regression analysis was applied for the multivariate risk factor analysis. Difference were considered statistically significant at the level of $P<0.05$ (bilateral).

Results

Case inclusion and general information of patients

A total of 13327 TBI patients were found after consulting the medical charts of patients with TBI in the emergency department of our hospital in recent 5 years. According to the exclusive criteria, 3142 patients were finally included. Among these patients, there were 2019 males (64.3%) and 1123 females (35.7%). The patients' ages were from 17 to 84 years old and their average age was 57.7±8.3 years old. Five hundred and ninety three patients (18.9%) were aged 65 years or older and 2549 patients (81.1%) were younger than 65 years old. All together 1076 patients (34.2%) were found to have intracranial injury after undergoing cranial CT examination and 7 patients (0.2%) among them received further surgical treatments. However, the other 2066 patients

Table 1. General information of included cases

Variable	Frequency (percentage)
Total	3142
Sex	
Male	2019 (64.3%)
Female	1123 (35.7%)
Age	
≥65 y	593 (18.9%)
<65 y	2549 (81.1%)
Traumatic lesion on CT	
Yes	1076 (34.2%)
No	2066 (65.8%)

(65.8%) revealed no obvious intracranial injury (**Table 1**).

Analysis of risk factors of intracranial injury diagnosed with CT examination

Single factor analysis: In this study, seven factors of the finally-included 3142 patients (age, gender, history of alcoholism, nausea/vomiting, pupillary size, amnesia and skull fracture diagnosed by physical examination) were analyzed. The results were as follows: among 593 elderly patients (≥65 years), 63.6% of them were found to have intracranial injury while only 27.4% of patients younger than 65 years old were diagnosed with intracranial injury. And the statistical analysis showed that there was a significant difference between the two groups (P<0.001). Among 1105 patients who had the symptoms of nausea/vomiting, 48.6% of them were found to have intracranial injury while only 26.5% of 2037 patients without symptoms of nausea/vomiting were diagnosed with intracranial injury. And there was a significant difference between the two groups (P<0.001). Among 824 patients with different pupillary sizes, 77.3% of them were found to haveintracranial injury while only 18.9% of patients with normal pupillary sizes were diagnosed with intracranial injury. Therefore, there was a significant difference between the two groups (P<0.001). Among 805 patients with skull fracture, 67.8% of them were found to have intracranial injury while only 22.7% of patients without skull fracture were diagnosed with intracranial injury. And there was a significant difference between the two groups (P<0.001). As for gender, history of alcoholism and amnesia, we found no statistical significance after analyzing these three factors (P>0.05) (**Table 2**).

Multivariate analysis: For the factors which showed statistical significance in the single factor analysis, the multivariate unconditional logistic regression analysis was employed for the further analysis. And the results indicated that the advanced age, anisocoria, nausea/vomiting and skull fracture were all independent risk factors for the CT-diagnosed intracranial injury (P<0.001, **Table 3**).

Discussion

The therapeutic effects of TBI not merely depend on the severity of injuries, the correct and timely intervention after injury is equally important. Severe TBI always receives due attention and can be treated timely, but mTBI is difficult to be identified. Therefore, the patients' prognosis can be influenced and even their lives may be endangered if the potential damage in patients cannot be treated timely. Although the diagnosis and treatment of TBI patients have been significantly enhanced with the continuous improvement of modern medical diagnosis and nursing technology, how to further improve the diagnosis and treatment of TBI are still the focus of the whole society and the research highlights, because the injury site is special, the disease can develop rapidly and the prognosis of patients sustains severe.

CT examination is commonly used in the treatment of TBI, which can recognize the intracranial injury in time. In order to accurately and timely identify the severity of mTBI, prejudge the intracranial injury and then develop the reasonable measures of diagnosis and treatment, Canada developed the Canadian CT Head Rule (CCHR) [10], which has been widely applied in clinic. The high risk factors listed in the CCHR included: GCS score was <15 at 2 h after injury, suspected open or depressed skull fractures, any features of skull base fractures, vomiting ≥2 times and age ≥65 years old. In this study, we analyzed the clinical data of mTBI patients in the emergency department of our hospital from January 2010 to December 2015. And seven risk factors (age, gender, history of alcoholism, nausea/vomiting, pupillary size, amnesia, and skull fracture) which may be related to

Table 2. Single factor analysis for intracranial injury diagnosed by cranial CT in patients with TBI

Risk factor			Traumatic lesion on CT		χ^2	P
			Yes	No		
Total		3142	1076 (34.2%)	2066 (68.5%)		
Sex	Male	2019	679 (33.7%)	1340 (66.3%)	0.95	0.33
	Female	1123	397 (35.4%)	726 (64.6%)		
Age	≥65 y	593	377 (63.6%)	216 (36.4%)	297.23	<0.001
	<65 y	2549	699 (27.4%)	1850 (72.6%)		
Alcohol	Yes	2021	677 (33.5%)	1335 (66.5%)	1.41	0.24
	No	1121	399 (34.8%)	731 (65.2%)		
Amnesia	Yes	1772	627 (35.4%)	1145 (64.6%)	2.34	0.13
	No	1370	449 (32.8%)	921 (67.2%)		
Anisocoria	Yes	824	637 (77.3%)	187 (22.7%)	919.69	<0.001
	No	2318	439 (18.2%)	1897 (81.8%)		
Nausea/vomiting	Yes	1105	537 (48.6%)	568 (51.4%)	155.9	<0.001
	No	2037	539 (26.5%)	1498 (73.5%)		
Skull fracture	Yes	805	546 (67.8%)	259 (33.2%)	541.98	<0.001
	No	2337	530 (22.5%)	1807 (77.5%)		

Table 3. The result of logistic multivariate regression analysis

Risk factor	B value	*P* value	OR (95% CI)
Age	0.08	<0.001	3.97 (2.13-5.09)
Anisocoria	0.11	<0.001	2.72 (1.07-3.92)
Nausea/vomiting	0.01	<0.001	2.31 (1.25-3.64)
Skull fracture	0.13	<0.001	4.11 (1.43-8.52)

the intracranial injury had been screened out, collated and analyzed. On the one hand, the data of patients in China were applied to test the applicability of CCHR index in China's emergency department. On the other hand, its expansion study was also carried out. The statistical analysis showed that among the seven risk factors listed above, advanced age (≥65 years), nausea/vomiting, anisocoria, and skull fracture were all significantly correlated with the intracranial injury (P<0.001). The risk factors mentioned in the CCHR were also verified in our study. Therefore, we can conclude that the CCHR was also suitable for the TBI patients in China. And patients with skull fracture were often accompanied with intracranial injury, so it was quite necessary for them to undergo the CT examination for many times, which also revealed that skull fracture as an important predicting factor must attract the attention of clinicians [11].

Foreign studies also have found that nausea, vomiting and skull fracture can be high risk factors for intracranial injury among patients with TBI [12, 13]. The conclusion drawn from a new multicenter study in Germany suggested that anisocoria could also be regarded as a risk factor to predict the intracranial injury, which was consistent with this study [14]. Although this study was a single center, retrospective study, the patients included were all Chinese patients, which was better meet China's national conditions. And this study was also helpful to improve the accuracy of Chinese emergency department clinicians in judging the disease severity of potential critically ill patients, and then manage the dangerous patients to undergo the further CT or other examinations in order to avoid the occurrence of medical accidents. Diagnosing the potential intracranial injury at early stage, developing the reasonable interventions, moving patients with relatively severe conditions into the specialized wards in time or receiving further medical interventions are of great importance to improve the prognosis of patients, reduce the occurrence of adverse events, effectively reduce the clinical misdiagnosis rate during the medical triage process. In addition, we could apply all kinds of biomedical markers of TBI (S100-β, neuron-specific enolase (NSE), glial fibrillary acidic protein (GFAP), ubiquitin carboxyl-terminal hydrolase L1 (UCH-

L1) and so on) to identify the acute and non-acute TBI [15-20].

In conclusion, the advanced age, nausea/vomiting, anisocoria and skull fracture can be served as predictors for the intracranial injury, especially for mTBI patients whose intracranial injuries are difficult to be identified. At the same time, it can reduce radiation injuries and save medical resources. In view of the fact that this study is a single center, retrospective analysis and the number of samples is limited, there still need clinical studies with a multi-center and large number of samples to confirm the results of this study.

Disclosure of conflict of interest

None.

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