

## Evaluation of sensitivity and the specificity of Canadian CT head rule and New Orleans criteria in patients with head injury

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### RESEARCH

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### ABSTRACT

#### Background

Millions of people around the world are annually under emergency investigation due to severe head injuries. Computed tomography (CT) scans is a diagnostic procedure that can be done for most people.

#### Aims

This study is aimed to evaluate the sensitivity and the specificity of Canadian and New Orleans criteria in determining the rate of head injury.

#### Methods

To obtain the relationship between clinical symptoms and CT scan results, the required information was obtained by filling out the records and physical examination in the emergency department and the results from the patients were statistically analysed. Data needed to complete the questionnaire was collected from patient, the patient, their

concomitant examination, and the information in their medical records. The raw data from the questionnaire was analysed using SPSS version 17 software. In this study, after obtaining the CT scan results, the individuals were classified into two clinical criteria, New Orleans and Canadian, and their sensitivity and specificity were analysed using ROC curve analysis.

#### Results

ROC curve analysis data showed that the sensitivity and specificity of New Orleans criteria are 31 per cent and 69 per cent, respectively, and the sensitivity and specificity of Canadian criteria are 76 per cent and 74 per cent, respectively. Data shows that the Canadian curve has a significant difference compared to basic state (P-Value<0.05).

#### Conclusion

Despite abnormal CT scan results in patients with head trauma, there is a significant relationship between headache and a combination of symptoms in patients. The results can be used in decision-making on involved in performing a CT scan. ROC curve analysis also showed that the Canadian criterion has higher sensitivity and specificity for the diagnosis of severe head trauma compared to New Orleans criteria.

#### Key Words

Trauma, CT scan, New Orleans criteria, Canadian criteria, ROC curve

#### What this study adds:

##### 1. What is known about this subject?

Due to the side effects of excessive CT scans, some measures should be considered to avoid unnecessary CT scans.

##### 2. What new information is offered in this study?

There is a significant relationship between headache and a

combination of symptoms in patients.

### 3. What are the implications for research, policy, or practice?

ROC curve analysis also showed that the Canadian criterion has higher sensitivity and specificity for the diagnosis of severe head trauma compared to New Orleans criteria.

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## Background

CT Scan or computed Tomography scan was recognized in 1972 as one of the advanced medical imaging. Today, with the development of technology, CT has become as one of the most important tools in the field of medical diagnostics as well as an integral part in the diagnosis and even in the treatment of many diseases. The number of CT tests compared to other diagnostic methods is dramatically rising.<sup>1</sup> Studies have shown that despite the small number of CT tests (about 2 per cent of the beam diagnostic tests), the cumulative (total delivered) dose resulted from the CT tests includes 20 per cent of the total cumulative dose. The statistics in 1999 have been reported approximately 4 per cent and 40 per cent, respectively.<sup>2</sup> Mettler and colleagues conducted a research in 2000 and found that the cumulative dose has reached 67 per cent in some parts of CT in USA.<sup>3</sup> With excessive increase in the doses of experiments, the risk of various cancers increases due to ionizing radiation in CT exams, which endangers the public health. It is noteworthy to say that the effect of radiation on children is greater compared to adults, because the sensitivity of their tissues is more towards radiation. The purpose of this study is to provide some conditions to allow physicians to detect the risk for a percentage of patients by using some examinations and do not prescribing a CT as much as possible, and in the discretion to perform a CT scan, the test be done with the knowledge of dosimetric data and valid clinical reasons and according to the losses - benefits rule (especially for children). Several researchers have studied the performance or non-performance use of CT for patients with trauma as well as the relationship between clinical symptoms and device analysis, especially CT scan, such as a study conducted by Osmond et al., which was aimed to find a set of clinical rules with high sensitivity for decision-making in the performance or non-performance use of CT for patients with minor head trauma. CT findings showed that 159 patients (4.1 per cent) had brain damage and 24 patients (0.6 per cent) needed neurologic intervention. In this study, four factors were considered as high-risk factors (not reaching to GCS of 15 within 2 hours, suspected to skull open fracture, deteriorative headache and irritability) and three factors were considered as moderate risk factors (Large and marshy hematoma, some signs of basal skull fracture, serious injury

mechanisms). In terms of ability to predict, the cases needed intervention of Neurology, High-Risk Factors (100 per cent) and intermediate risk factors (98.1 per cent) were sensitive. High risk factors reduced the number of patients with need to CT to 30.2 per cent and intermediate risk factors to 52 per cent.<sup>4</sup> In another study by Ehsaei et al. (1384), the relationship between CT scan findings and the clinical signs and symptoms of patients with cranial trauma were studied with Glasgow Coma Scale (GCS). They showed that CT scan is not necessary for patients with mild symptoms; moreover, the patients with lower GCS and severe cranial trauma signs had more abnormal CT scans. Therefore, it can be said that unnecessary use of CT scan tests could be reduced on the basis of clinical signs and symptoms.<sup>5</sup> In this study, the sensitivity and the specificity of two diagnostic methods were evaluated. The methods are based on New Orleans Criteria: (Headache, vomiting, older than 60 years, amnesia, trauma above the collarbone, and seizures) and Canadian criteria (GCS >15, the risk of skull open fracture, vomiting, any sign of basilar skull fracture, Age ≥65, amnesia, dangerous mechanism of trauma). In this study, ROC chart analysis (Receiver operating characteristic) was used to assess the sensitivity and specificity of New Orleans and Canadian criteria (Figure 1).<sup>6,7</sup>

## Method

In the present study, which is an observational analysis study, among the patients referred to Hospital's CT scan department due to minor head trauma, 264 patients with minor head trauma were included following the CT scan results (positive or negative). The subjects consisted of 139 individuals with positive CT scan result in addition to 125 individuals who have had head trauma but their CT scan result was negative. Then all of the subjects were evaluated in terms of the two criteria (Canadian and New Orleans). So that if an individual has the characteristics of New Orleans criteria, the subject was positive in terms of the criteria, if not, it was negative. This process was applied to each individual for Canadian criteria. To draw ROC curve, the samples of patients and healthy individuals were selected for the test to be measured on. In the following, the changes range of variable was determined and then in successive cut-off points within the range, the sensitivity and false positive (a minus specificity) were determined.

Cut-off points means the various sets of assay method or in other words the various conditions of the test: for example, the Canadian assay method has a two-stage rating scale; the positive in which the individual has the criteria symptoms and the negative in which the individual lacks the criteria symptoms, therefore, there is only one cut-off point in this

case in which the test is a two-stage process, where a score below the Cut-off point is negative and above is positive. A sign (Area) which is equivalent to the area under the ROC curve indicates test diagnostic power. In higher diagnostic test power, the ROC curve will be above the square's diameter and closer to ideal conditions (area=1). In ROC curve, a test with diagnostic power matches the square's diameter and a test with reversed diagnostic power locates below the diameter.<sup>8</sup>

## Results

In the present study conducted on 139 patients, 79.9 per cent of the population were male and 20.1 per cent were women. Also in this study, the age ranged from 30 to 45 years had the greatest frequency (31.7 per cent of the target population) and the age ranged from 14–29 years had the lowest frequency (18.7 per cent of the target population). Variable of trauma mechanism is a qualitative variable in which the highest frequency belonged to automobile driver (35.5 per cent) and the lowest frequency to falling (9.4 per cent). The CT scan results also showed that subdural had the maximum frequency (31.7 per cent) and skull fracture data without hematoma had the lowest frequency (2.9 per cent). Subdural, which is one of the CT scan results, had the most frequency and played the most important role in the development of clinical symptoms, it also became clear that automobile drivers are mostly at risk for head trauma. In this study, it was also found that for subjects in the age between 14–29 years the most and the least frequent CT scan results belong to the epidural and fracture, respectively. In the age between 30–45 years the most frequent CT scan results belonged to the Epidural and SAH (sub-arachnoid haemorrhage), and fracture had the lowest frequency. This is while Subdural CT were most abundant in the age group between 46–61 years and 62–77 years. However, fracture also had lowest frequent CT scan results like the previous age groups. In this study, ROC curve analysis was used to assess the sensitivity and specificity of New Orleans and Canadian criteria. To analyse the sensitivity and specificity of New Orleans criteria, 264 patients were selected as the procedure described in the methods.

ROC curve was drawn after considering the desired criteria (curve No.1 belongs to New Orleans and Canadian criteria, the blue line indicates the New Orleans characteristic and Green Line indicates the Canadian characteristic) and the difference of any diagnostic procedures with basic state, which is square's diameter in ROC curve, was drawn. The area under the curve of each criterion was also drawn. The data showed that Canadian curve has a significant difference compared to basic state (P-Value<0.05) (Table 1). In this

study, the sensitivity and the specificity of New Orleans method were reported 31 per cent and of 69 per cent, respectively. The sensitivity and specificity of Canadian method were also reported 76 per cent and 74 per cent (Table 2).

## Discussion

More than a million people in the United States are annually under emergency investigation due to severe head injuries.<sup>9,10</sup> Most reports concerning these damages are in children less than Five years old and adults over 85 years old. According to the previous studies conducted in this field, 80 per cent of these injuries are minor head injury, 10 per cent are moderate head injury and the remaining 10 per cent are severe head trauma. 20 per cent of individuals who have suffered such damages are hospitalized, of which 200,000 death or permanent disability are created.<sup>11,12</sup> Damage to the head (head trauma) is the main cause of traumatic death in patients less than 25 years old and includes about one third of trauma deaths are.<sup>13</sup> In this study, the variable of trauma mechanism is a qualitative variable in which the highest frequency belongs to automobile driver (35.5 per cent) and the lowest frequency to Falling (9.4 per cent). It also became clear that automobile drivers are mostly at risk for head trauma.<sup>14,15</sup> The relationship between clinical symptoms and CT scan results were also analysed based on gender and the results indicated a significant relationship between clinical symptoms and CT scan results based on group gender. Jacob and colleagues demonstrated that the patient's age, extracranial injury and how long the injury goes unrepaired are the main factors to predict a patient's efficiency condition and the presence of facial fracture and the number of bruises with bleeding are the main factors to determine the need for CT.<sup>16,4</sup>

The present study also showed a significant relationship between individuals' age and the CT scans results obtained. Similar results obtained in this study are in consistent with the studies conducted by Shireen and Haydel.<sup>17,18</sup> Ibanez and colleagues also reported that the CT scan results relates to the age over 65 years old.<sup>19</sup> In a study by One and colleagues, the relationship between CT scan results and the age older than 60 years was reported.<sup>20</sup> The sensitivity and the specificity of New Orleans method were reported 31 per cent and of 69 per cent, respectively. The sensitivity and specificity of Canadian method were also reported 76 per cent and 74 per cent, which are similar to a number of other studies. For example, in a study conducted by Kavalci and colleagues (2014), the sensitivity and specificity of New Orleans criteria were reported 88.2 per cent and 6.9 per cent, respectively. The sensitivity and the specificity of

Canadian criteria reported in this study were 76.4 per cent and of 41.7 per cent, respectively.<sup>21</sup>

### Conclusion

Despite abnormal CT scan results in patients with head trauma, there is a significant relationship between headache and a combination of symptoms in patients. The results can be used in decision-making on doing CT scan. ROC curve analysis also showed that the Canadian criteria has more sensitivity and specificity for the diagnosis of severe head trauma compared to New Orleans criteria. Therefore, the results of our study show that Canadian criterion is more sensitive for decision-making on performing CT scan in the patients with head trauma.

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### PEER REVIEW

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### CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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### ETHICS COMMITTEE APPROVAL

Ethical approval for the study was obtained from Mashhad University of Medical Sciences and approval references number is Ir.mums.fm.rec.1395.87.

**Table 1: The area under the ROC curve**

Criteria type	The area under the curve	S.E	P-Value
New Orleans	0.497	0.065	0.962
Canadian	0.741	0.056	0

**Table 2: The Sensitivity and the specificity of New Orleans and Canadian methods**

Test Result Variable(s)	Positive if Greater Than or Equal To a	Sensitivity	1 – Specificity
New Orleans	2	0.31	0.31
Canadian	2	0.762	0.263

**Figure 1: The ratio of the diagnosis of brain damage in New Orleans and Canadian criteria**

