



## A COMPARISON OF CANADIAN HEAD CT RULE AND NEW ORLEANS CRITERIA IN MILD TBI (TRAUMATIC BRAIN INJURY) PATIENTS IN A TERTIARY HOSPITAL IN KARACHI, PAKISTAN.

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### INTRODUCTION

Mild traumatic brain injury is a neurological disorder that happens after sustaining a trauma to the body in which the patient experiences a normal or minimally altered level of consciousness along with a Glasgow comma scale of 13-15, which may or may not be accompanied by post traumatic amnesia for more than 60 minutes.<sup>1</sup> A normal neurologically functioning individual will score 15/15 on a Glasgow Coma Scale (GCS). Hospitalization or neurosurgical intervention may be required in mild TBIs for intracranial complications that are detected on computed tomography scan (CT scan).<sup>2</sup> So, CT scan provides a fast and reliable method for the diagnosis of such complication. But too much use of CT scan could subject the patient to excessive radiation while too little could potentially miss fatal lesions.

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**ABSTRACT... Objectives:** The aim of our study is to compare the Canadian Head CT rule to New Orleans Criteria, to find a more efficient guideline in predicting the important CT findings in mild Traumatic Brain Injury (TBI) cases. **Study Design:** Observational study. **Setting:** Dow University of Health Sciences, Civil Hospital Karachi. **Period:** 6 months from June 2017 to December 2017. **Material & Methods:** We divided a sample of 150 mild TBI patients into two groups of Glasgow coma scale (GCS) scores of 13-14 and GCS score of 15. Then using a separate scoring system for both the CCHR and NOC, we evaluated their accuracy and efficiency in predicting mild TBI through a total of 7 major clinical items. Specificity and sensitivity were calculated to compare both the scoring systems and results were compared through univariate and multivariate analysis. A p value of less than 0.05 was considered to be statistically significant. **Results:** We analyzed the relation between clinical items and important CT findings and found that the CCHR, through multivariate analysis, was more closely associated with important CT findings. We also found that the factors of age, and the Glasgow comma scale score were also strong indicators of important CT findings regardless of which guideline was used. **Conclusion:** In our study, we found CCHR to be a stronger predictor of important CT findings than the NOC. We found that CCHR performed significantly higher than the NOC.

**Key words:** Canadian Head CT Rule, CT scans, Glasgow Comma Scale, Mild TBI, New Orleans Criteria, X-ray.

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In order to omit the unnecessary usage of CT scans, several clinical guidelines have been deduced for patients with mild TBI. In a review article published by Harnan et al.<sup>3</sup> Canadian CT Head Rule and the New Orleans Criteria are the most widely used guidelines for predicting clinically important CT scan findings in mild TBI patients. In a recent comparison in western countries which reported<sup>4,5</sup>, a good balance between the sensitivity and specificity of the Canadian CT Rule (CCHR) versus New Orleans Criteria (NOC). Mild TBI is a common occurrence in the western countries where there are about 100-300 incidents per 100,000 people.<sup>6,7</sup> So, significant comparisons and studies have been done in the field, however, such studies have not been done or reported in Pakistan which has a very high number of reported CT scans and subsequently is at high risk for cancer from

diagnostic X-rays. Hence the aim of our study is to compare the Canadian CT Head Rule and the New Orleans Criteria in their efficiency of predicting important CT findings in Pakistani patients with mild traumatic brain injury. The comparison will attempt to weigh the contribution of both the guidelines through a two-scoring system based on the overall performance of each guideline.

## MATERIAL & METHODS

The study was conducted at Dow University of Health Sciences, Civil Hospital Karachi for period of 6 months from June 2017 to December 2017. An observational study design and a convenience sampling method was used. Our study was approved by the institution review board and consent was taken from patient's caregiver. The same inclusion criteria used in the western countries' studies<sup>8,9,10</sup> was used in our comparative study in order to confirm that CCHR had a better performance than the NOC. So, 150 patients with mild TBI, who were admitted to our hospital and fulfilled the following criteria were included in the study: 1) less than 24 hours of TBI, 2) age more than 17 years, 3) showed one of the signs of the risk factors stated in the Canadian CT head rule and the New Orleans criteria. Age, sex and means of accident were included in the demographic data of the 150 patients, recorded in a predesigned proforma. The age range was 71 years with a minimum of 17 years and a maximum of 88 years, sex- male/female and means of accident was road traffic accident in 47.9% of the cases, falls in 44.4%, and other causes in 7.7% of cases. Penetrating brain injury was reported in none of the cases.

In our study design for NOC, the 7 clinical items sought in all the patients were- headache, seizure, anterograde amnesia, injury above the clavicles, intoxication (by drugs or alcohol), age '>60' years and vomiting.<sup>7</sup> Since the institution where we conducted our research did not perform blood toxicology tests in all traumatic brain injury cases, so for intoxication, we used other visible evidences for detection, like nystagmus, slurring of speech etc.<sup>8</sup> On the other hand in CCHR the 7 clinical items sought for in each patient were- Glasgow Comma Scale of less than 15 after 2

hours of admission, occurrence of vomiting for more than two times, age '>65' years, an open or depressed skull fracture or a suspicion of one, retrograde amnesia>30 minutes, signs of basal skull fracture and dangerous mechanism.<sup>4</sup>

Since there are 7 clinical items in both the Canadian CT head rule and the New Orleans criteria, we devised two separate scoring systems, each with a score of 0-7, and subsequently named them the Canadian Rule score and New Orleans score. For both, a score of +1 was given if the patient met conditions for one of the seven clinical items. Each patient was evaluated for both the CCHR and NOC. Two neurosurgeons reviewed the CT screenings for any anomalies defined as acute brain findings, which would require medical attention and hospitalization for further follow up.<sup>4,8,10</sup> The attending physicians were unaware of the clinical data during that time. The brain injuries seen on the CT were deemed important based on the definition by Stiell et al.<sup>12</sup>, unless the patients was neurologically intact and was detected with one of the following lesions on its CT: 1) isolated pneumocephaly, or 2) closed depressed skull fracture not through the inner table, 3) solitary contusion less than 5mm in diameter, 4) smear subdural hematoma less than 4-mm thick or 5) localized subarachnoid bleed less than 1-mm thick.

For predicting the important CT findings in mild traumatic brain injury cases and to test the reliability, first we calculated the sensitivity and the specificity of the CCHR and the NOC. Upon confirming that our results are consistent with those of the western population's studies, we then moved on to the analysis of our scoring systems. The New Orleans criteria was originally deduced for patients with a Glasgow coma scale score of 15<sup>12</sup>, with an assertion that the case with a score of less than 15 will undergo CT scanning. On the other hand, Canadian CT head rule was deduced for patients with Glasgow coma scale of 13-15.<sup>5</sup> To score equal assessment, we provided the clinical scenario to both the guidelines upon which they were devised on. So, setting 1 with the patients with a GCS score of 15 (n=73) were evaluated on NOC while setting 2 with GCS of

13-15 (n=102) were evaluated on CCHR. We analyzed the data using IBM SPSS software version 20.0 and considered a p value of less than 0.05 as statistically significant. Further, we used U test to examine any relationship between the scores of our clinical settings for CCHR and NOC and those of the important CT findings. Then we compared the two scoring systems on basis of their performance in predicting any important CT findings by applying two tests. We used the two-scoring system as independent variable and multiple logistic regression with important CT findings as 'true' and 'false' as dependent variable. We generated the areas under the receiver characteristic curve, in order to measure the comparative performance of both scoring systems in predicting important CT findings.

To deduce which clinical finding out of all the 14 clinical items (7 each), could alone predict important CT findings, multiple and univariate logistic regressions were used. Minimum number of events per independent variable was set 10 in order to maintain the statistical power of multiple logistic regression.<sup>13,14</sup> So, we used a technique that showed P value less than or equal to 0.20 in the univariate analysis of the fourteen clinical items with multiple logistic regression. Out of the 73 patients evaluated based on NOC, in the GCS score 15 group, 15 (~20%) patients showed important CT findings, which is below the minimum value of needed dependent events to apply multiple logistic regression.<sup>13,14</sup> From the GCS score 13-15 group, in which patients were evaluated on basis of the CCHR, of the 102 patients, 35 (~34%) patients showed important CT findings. Hence, we did not look for the independent items that predicted important CT findings.

## RESULTS

In the Glasgow Comma Scale score- 15, in finding important CT findings, an equal sensitivity of 91.8% was observed. Although, the NOC fell behind on its accuracy (18.6%) and specificity (33.1%) against 23.3% and 36.9% for specificity and accuracy respectively for CCHR. On the other hand, for the group with GCS of 13-15, the NOC showed higher sensitivity (96.9%),

lower specificity (10.1%) and lower accuracy (38.7%), versus CCHR having a sensitivity of 88.9%, specificity of 25.4% and accuracy of 48.1%. From the 150 cases, 52 (35%) exhibited clinically important CT findings. The top two CT findings of mild TBI patients were intraventricular/subarachnoid hemorrhage at 65.3% and brain contusion at 44.9%. Refer to Table-I for other important CT findings. Those cases that had significant CT findings, the patients notably, more often than less, had a higher age with  $P = <0.0001$ , gender female with  $P = 0.0022$  and mechanism of injury being fall with  $P = 0.0030$ . Furthermore, a positive correlation was observed for CCHR and important CT finding in the group (CCHR univariate  $P = 0.0043$ , multivariate  $P = 0.0128$ ) versus NOC (univariate  $P = 0.09$ , multivariate  $P = 0.69$ ), keeping in mind that the GCS-15 was originally designed for NOC to perform fairly.

Also, it's interesting to note that the AUC (Area under the curve) value for NOC (0.63) was lower than that of the CCHR's (0.73). Through multivariate analysis, the CCHR showed a stronger statistical significance in comparison to the NOC (CCHR's  $P = 0.030$  vs NOC's  $P = 0.6584$ ). But in univariate analysis, both the CCHR and NOC exhibited strong relation to significant CT findings with a P value of 0.0001 and 0.0063 respectively. Also, the AUC for NOC was lower than the AUC for CCHR at 0.63 and 0.69 respectively. From the clinical items fed into univariate and multivariate analysis, the age was the most significant predictor of mild TBI with a P value of 0.0001 (refer Table-II and III). Next significant predictor was the Glasgow comma scale of less than 15 at 2 hours post injury.

Clinically Important CT Findings	Percentage of Patients	Number of Patients
Intraventricular / subarachnoid hemorrhage	65.3%	33
Brain contusion	44.9%	23
Skull fracture	32.7%	17
Subdural hematoma	30.6%	15
Epidural hematoma	6.1%	3
Midline shift	6.1%	3
Basal cistern compression	4.0%	2

**Table-I. Important CT findings from the 49 patients with mild TBI.**

Clinical Items	95% CI (upper and Lower Quantile Values)	Number of Times Neurological Intervention used (Surgery)	Fisher Exact Test Probability Value(P)
<b>For age 65 and above</b>			
Age factor (>60)	2.6-14.6	6	0.0001
Signs of basal skull fracture	0.3-3.6	1	0.84
Suspicion of open or depressed skull fracture	0.6-3.9	2	0.31
GCS of less than 15 at 2 hours after injury	1.4-10.9	4	0.008
Visible trauma above clavicle	0.5-4.4	2	0.46
Vomiting	0.6-85	4.2	0.15
<b>For age less than 65</b>			
Age factor (under 60)	2.7-14.9	6	0.0001
Signs of basal skull fracture	0.3-3.6	1	0.93
Suspicion of open or depressed skull fracture	0.7-4.4	2	0.22
GCS of less than 15 at 2 hours after injury	1.4-10.8	4	0.0098
Visible trauma above clavicle	0.6-4.9	2	0.37
Vomiting	0-1.8	4	0.20
<b>Table-II. Items independently predicting important CT findings using multiple logistic regressions.</b>			

Clinical Item	Significant Finding Positive Patients (n=51)	Significant Finding Negative Patients (n=99)	Fisher Exact Test Probability Value(P)
<b>For CCHR</b>			
Dangerous mechanism (n=75)	27	49	0.8603
Suspicion of skull fracture (n=48)	22	28	0.1343
Age greater than / equal to 65 (n=45)	28	19	0.0001
GCS less than 15 at 2 hours post injury (n=27)	17	12	0.0050
Signs of basal skull fracture (n=21)	12	11	0.1174
Retrograde amnesia (n=17)	8	11	0.7748
More than 2 incidents of vomiting (n=4)	3	5	1.000
<b>For NOC</b>			
Visible trauma over the clavicle (n=107)	42	67	0.1608
Headaches (n=66)	27	41	0.3754
Age more than 60 (n=54)	32	24	0.0001
Intoxication (n=33)	13	22	1.000
Anterograde amnesia (n=22)	9	15	1.000
Vomiting (n=11)	3	10	0.1638
Seizure (n=0)	0	0	1.000
<b>Table-III. Relationship between clinical items used in CCHR and NOC and clinically significant CT findings using univariate analysis.</b>			

## DISCUSSION

In this study, we found out that patients with GCS-15, both CCHR and the NOC had high sensitivities. CCHR had a higher specificity for important CT findings in comparison to NOC while for patients

in GCS 13–15 group, Canadian CT head rule had lower sensitivity but a higher specificity than New Orleans Criteria. Upon careful analysis, we found that the results were consistent with the studies conducted in the west<sup>8,12</sup>, which concluded that



the unnecessary radiation from the CT scans could be avoided by using an alternative yet accurate and efficient way of finding the brain injuries in mild TBI cases. Also, the two separate scoring systems used in the study for both the guidelines meant we compared their accuracy in predicting important CT finding through their strengths. We compared them through cumulative contribution of each individual clinical terms for further accuracy. Through univariate analysis of GCS score 13-15 group, we found both CCHR and NOC, both were associated significant CT findings. This result was found to be consistent with previously conducted studies and literature, hence reinforcing the pros of using the guidelines. Also, our study proved the clinical recommendation of superiority of CCHR versus NOC, as proven by previous large-scale western studies.<sup>9</sup>

Out of all the clinical items used in our study, we found that age, in both the guidelines was the most significant predictor mild TBIs, and this result was also consistent with the previous literatures.<sup>8,12</sup> For CCHR, the GCS score of less than 15 at 2 hours post injury was another important clinical item that predicted TBIs, because it represented any short-term neurological changes that occurred in the body after the injury occurred. This aided not only in predicting brain lesions but also whether there is a need for a surgical intervention or not. Through the data, we found that most TBI patients who though did fulfill the criteria of one of the guidelines, did not undergo CT scans. Hence, we believe that both the guidelines should be implemented in Pakistan. In comparison to other western studies, we found that our study had a higher prevalence of important CT findings. Given that the mean age of our patients was 50 years, while for other studies it was less<sup>4,5,9</sup>, and this was reflected in our results as well, as the age of patients with important CT findings was higher than that of patients with no important CT findings. Existing literature also supports our results, as higher age is a huge risk factor for important CT findings.

Our study also had few limitations such as the data being sourced from one hospital, the TBI

management could influence some of our results. Also, the design could affect some clinical items. But since we use a common template to extract the targeted clinical data, those limitations were largely minimized by using the exact definitions of the clinical pointers, as proposed by their authors.<sup>4,5</sup>

## CONCLUSION

In our study of 150 patients with mild TBI in a tertiary health care facility in Pakistan, we deduced two scoring systems from CCHR and NOC. We found that CCHR's overall performance and accuracy was greater than the NOC as when limited to the patients with GCS score of 15, CCHR could reduce unnecessary CT scans. All our results were found to be consistent with many previous large-scale studies conducted in the west.








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3	Asim Rehmani	Data collection, write up, analysis, literature review.	
4	Shiraz Ahmed Ghori	Data collection, literature review, initial write up.	
5	Atiq Ahmed Khan	Data collection, literature review, initial write up.	
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