nmj
Nigerian Medical Journal
NIGERIA MEDICAL ASSOCIATION
Print ISSN 0300-1652, E-ISSN 2229-774X

Original Research

Predicting Clinically Significant Brain Injuries Following Mild TBI: A Comparative Study of Canadian CT Head Rule and New Orleans Criteria at a National Trauma Centre.

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Abstract

Background: Mild traumatic brain injury (mTBI) is one of the most common injuries treated at any trauma centre. Whereas the general use of CT for all patients with mTBI is inefficient and wasteful, the omission of a clinically important brain injury is not desirable. Several guidelines have been developed to assist physicians in determining who actually needs a head CT. For this reason, the Canadian CT Head Rule (CCHR) and the New Orleans Criteria (NOC) were compared in this study on their efficacy in predicting surgically significant brain injuries and the need for neurosurgical intervention.

Methodology: The research was a prospective cross-sectional study at a level 1 trauma centre that received ethical approval from the Hospital. Consenting adult patients who presented with mild TBI within 24 hours were recruited. They were assessed with the NOC and CCHR, whose decisions were compared with each other and with CT head findings.

Results: A total of 103 patients were successfully enrolled, males were 91 and females were 12, with a mean age of 32.48±12.27 years old. The NOC guideline had a sensitivity (88.6%), specificity (21.4%), positive predictive value (47.0%) and negative predictive value (70.6%) of clinically significant brain injury; while CCHR guideline showed sensitivity (86.4%), specificity (30.4%), positive predictive value (49.4%) and negative predictive value (73.9%) of clinically significant brain injury (table 3), however, statistically were not significantly different with P-value of 0.39. Similarly, there was no statistically significant difference between the two guidelines for the need for neurosurgical intervention, as the P-value was 0.48.

Conclusion: Following the findings, this study suggests that either NOC or CCHR is safe to be used for ordering a head CT for patients with mild TBI.

Keywords: mild traumatic brain injury, computerized tomography scan, clinical decision rule, predictive value, New Orleans Criteria, Canadian CT Head Rule, Nigeria.

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How to Cite: Kpuduwei SPK., Yusuf AS., Ismail NJ., Adebiyi JA. Predicting Clinically Significant Brain Injuries Following Mild TBI: A Comparative Study of Canadian CT Head Rule and New Orleans Criteria at a National Trauma Centre. Niger Med J 2025; 66 (6): 2203-2211 https://doi.org/10.71480/nmj.v66i6.1088

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Introduction

Mild traumatic brain injury (mTBI) accounts for approximately 70–90% of all traumatic brain injuries presenting to emergency departments worldwide.[1] M**ild TBI can be defined** as a blunt injury to the head with loss of consciousness less than 30 minutes following the injury, disorientation, posttraumatic amnesia of less than 24 hours following the injury, with or without transient loss of focal neurological deficit and GCS 13-15.[2] Despite the low prevalence of clinically significant intracranial injury in this group, cranial computed tomography (CT) remains widely overutilized.[3] Contemporary studies from high-income countries estimate that fewer than 10% of CT scans performed for mTBI demonstrate clinically important findings, raising concerns regarding unnecessary radiation exposure, increased healthcare costs, and emergency department overcrowding.[4,5] On the other hand, due to a wide range of clinical manifestations, which are classified as mild, there is a tendency to ignore the neurosurgical consult. Whereas the general use of CT for all patients with mTBI is inefficient and wasteful, the omission of a clinically important brain injury is also not desirable.[2]

In response to this challenge, validated clinical decision rules were developed to guide selective CT use. The Canadian CT Head Rule (CCHR) and the New Orleans Criteria (NOC) remain the two most extensively studied tools. While early derivation and validation studies demonstrated excellent sensitivity for clinically important brain injury,[6,7] modern clinical practice demands ongoing reassessment of these tools within evolving imaging environments, diverse populations, and resource-limited settings. Over the last decade, multiple large-scale, prospective, and multicenter studies have reaffirmed the diagnostic safety of both rules while highlighting differences in specificity and implementation efficiency.[8,9] In particular, updated analyses by Stiell et al. and Papa et al. have demonstrated that while both rules maintain near-perfect sensitivity, the CCHR consistently offers superior specificity and greater CT reduction potential. (9) These findings have influenced international guidelines, including the 2020 American College of Emergency Physicians (ACEP) Clinical Policy, which endorses the use of validated decision rules for CT stewardship in adult mTBI.[10]

In low- and middle-income countries (LMICs) such as Nigeria, the implications of CT overuse are magnified. Limited scanner availability, high out-of-pocket costs, and competing trauma burdens necessitate rational imaging strategies. However, local validation data remain sparse, and decision-rule adoption is inconsistent across African emergency settings.[11]

This study, therefore, evaluates the performance of the Canadian CT Head Rule and New Orleans Criteria in an urban Nigerian tertiary hospital, with particular emphasis on their contemporary relevance, diagnostic accuracy, and potential to reduce unnecessary CT imaging in a resource-constrained environment by predicting surgically significant brain injuries and the need for neurosurgical intervention.

Patients And Methods

The research was a cross-sectional study of all consenting adult patients with mild TBI who presented to the Trauma Centre within 24 hours of injury from August 2022 to April 2023. The National Trauma Centre is situated in the National Hospital and serves the Federal Capital Territory of Nigeria. These patients presented with a history of loss of consciousness, disorientation or amnesia and a GCS of 13-15. The patients were assessed at presentation by the emergency physicians and were subsequently screened with both the Canadian CT Head Rule and New Orleans Criteria to determine if they needed a head CT scan or not, according to the criteria, before they were added to the study. This screening does not interfere with trauma management routines so as not disadvantage any patient. Only consenting patients

Niger Med J 2025;66(6): 2042– 2056,**ISSN**: 0300-1652, **E-ISSN**: 2229-774X, **Publisher**: Nigerian Medical Association. Nov.,–Dec., **2025**

(who gave written or verbal consent either by self or through responsible relatives) were recruited into the study. Since patient selection was not automatic on presentation to the Trauma Centre, those non-consenting patients are not accounted for in this publication. Following the head CT, patients were assessed again for CT findings of significant brain injury (any brain injury that required hospital admission and observation or neurosurgical follow-up) and need for neurosurgical intervention (ICU admission, surgical procedure including ICP monitoring or death within 30 days).[2,12] Data were entered into IBM SPSS^{R} and analyzed using version 25.0. Ethical clearance was obtained from the Hospital's Research Ethics Committee on 7th December 2020 with number NHA/EC/108/2020.

Results

A total of 103 patients were enrolled; there were 91 males and 12 females with a male-to-female ratio of 7:1. The mean age of the patients was 32.48±12.27 years, with an age range of 16 to 76 years. Only 3 (2.9%) patients were above the age of 60 years (Table 1).

Table 1.0: Socio-demographic Characteristics

Variable	**Gender**		
Age group (years)	**Male**	**Female**	**Total**
16 – 20	18	3	21
21 – 30	24	5	29
31 – 40	29	2	31
41 – 50	16	0	16
51 – 60	3	1	4
> 60	2	1	3
Total	**91**	**12**	**103**

Injury above the clavicle (64, 62.1%), headache (42, 40.8%), GCS < 15 after 2 hours (48, 46.6%), dangerous mechanism of injury (36, 35.0%) and amnesia (36, 35.0%) were the more common risk factors of the two decision rules (Table 2).

Table 2.0: Clinical Characteristics with respect to the decision rules

NOC Factors	**Freq**	**Percent (%)**	**CCHR Factors**	**Freq**	**Percent (%)**
Headache	42	40.8	GCS < 15 After 2 Hrs	48	46.6
Vomiting	24	23.3	Suspected Open or Depressed Skull Fracture	20	19.4
Age > 60	3	2.9	Any Sign of Basal Skull Fracture	14	13.6

Drug or Alcohol Intoxication	9	8.7	2 or More Episodes of Vomiting	16	15.5
Persistent Antegrade Amnesia	22	21.4	Age > 65 Years	2	1.9
Visible Trauma Above Clavicle	64	62.1	Retrograde Amnesia ≥30min	36	35.0
Seizure	7	6.8	Dangerous Mechanism of Injury	36	35.0

The most common mechanism of injury was a road traffic accident (Figure 1). A total of 45 (43.7%) of the study population had clinically significant brain injury, and 21 (20.4%) had need for neurosurgical intervention (with the intention to treat).

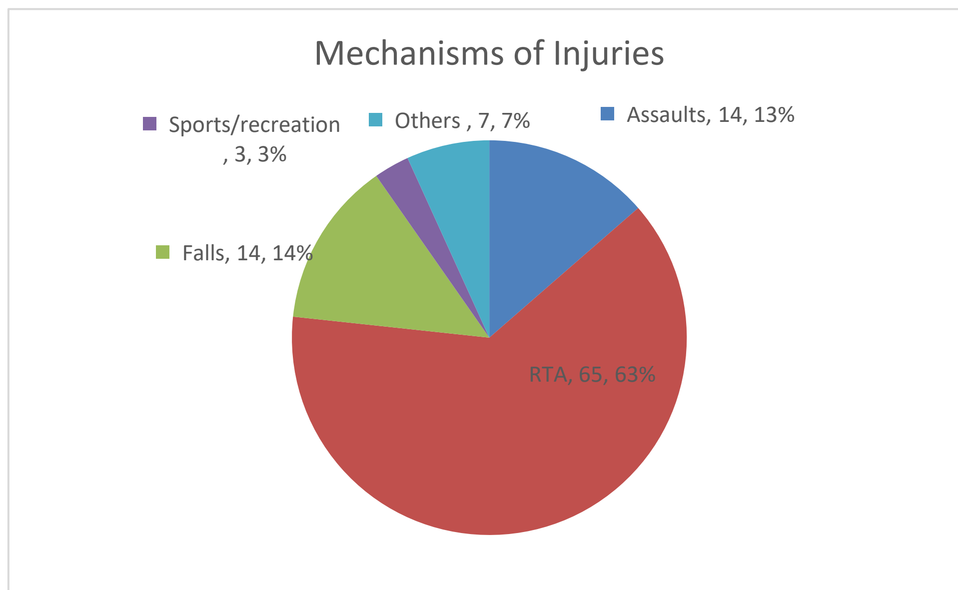

Figure 1: Mechanism of injuries

The most common pathology found on CT was skull fracture (29; 28.2%), out of which 3 were depressed, and 1 was comminuted with some bone loss. Skull fracture was followed by cerebral contusions (19; 18.4%) as the 2nd most common pathology, then extradural haematoma (15.5%), cerebral edema (10.7%), pneumocephalus (7.8%), and subarachnoid haemorrhage (5.8%). The least common pathology found on cranial CT was an acute subdural haematoma. The NOC guideline had a sensitivity (88.6%), specificity (21.4%), positive predictive value (47.0%) and negative predictive value (70.6%) of clinically significant brain injury; while CCHR guideline showed sensitivity (86.4%), specificity (30.4%), positive predictive value (49.4%) and negative predictive value (73.9%) of clinically significant brain injury (table 3).

Table 3.0: Predictive Values of clinically significant brain injury on CT scan

Clinical Rules decision & outcome		Yes		No		P-Value
		NOC	CCHR	NOC	CCHR	
Eligible for CT	Count	**39**$^{+tp}$	**38**$^{+tp}$	44	39	
	% +ve prediction	47.0%	49.4%	-	-	
	% outcome (**sensitivity**)	88.6%	86.4%	-	-	
Not eligible for CT	Count	5	6	**12**$^{-tn}$	**17**$^{-tn}$	**0.39**
	% -ve prediction	-	-	70.6%	73.9%	
	% outcome (**specificity**)	-	-	21.4%	30.4%	

+tp - true positive, -tp - true negative, CT- computerized tomography

Notwithstanding, there was no statistically significant difference between the two decision rules (P-value = 0.39). For predicting need for neurosurgical intervention, the sensitivity, specificity, positive predictive value, and negative predictive value under the NOC guideline were 95.0%, 20.0%, 22.9% and 94.1%, respectively; while those under the CCHR guideline were 90.0%, 26.3%, 23.4% and 91.3%, respectively (Table 4).

Table 4.0: Predictive Values for Need for Neurosurgical Intervention.

Clinical Rules decision & outcome		Yes		No		P-Value
		NOC	CCHR	NOC	CCHR	
Eligible for CT	Count	**19**$^{+tp}$	**18**$^{+tp}$	64	59	
	% +ve prediction	22.9%	23.4%	-	-	
	% outcome (**sensitivity**)	95.0%	90.0%	-	-	
Not eligible	Count	1	2	**16**$^{-tn}$	**21**$^{-tn}$	**0.48**

for CT	% -ve prediction	-	-	94.1%	91.3%	
	% outcome **(specificity)**	-	-	20.0%	26.3%	

+tp - true positive, -tp - true negative, CT- computerized tomography

Similarly, there was no significant difference between the two decision rules (P- value = 0.48). The Receiver Operative Characteristics (ROC) curve was also plotted to compare both rules to CT findings, which is the gold standard of diagnosis of head injury (Figure 2), showing a less than 50% cut off mark.

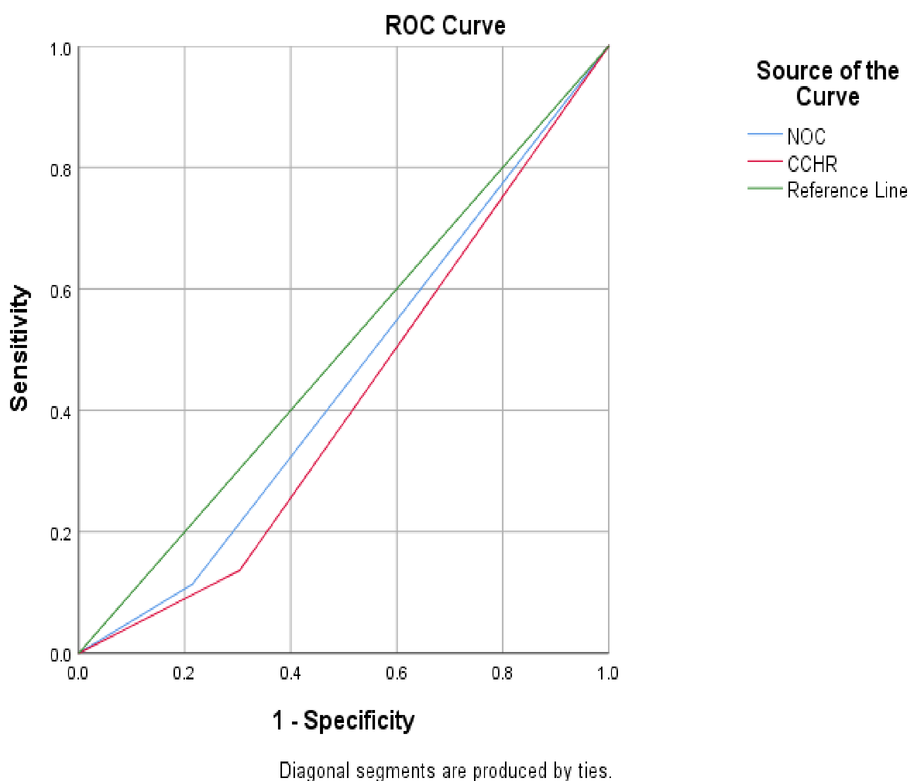

Fig.2: ROC for comparison between NOC and CCHR for clinically significant brain injury

Discussion

This study demonstrates that both the New Orleans Criteria and the Canadian CT Head Rule maintain high sensitivity (88.6% and 86.4%, respectively) for clinically significant intracranial injury among Nigerian patients with mild traumatic brain injury, while CCHR had a higher specificity (30.4%) than NOC (21.4%) for the same outcome. In addition, the study shows that both NOC and CCHR have low positive predictive values (47.0% & 49.4%) but high negative predictive values (70.6% & 73.9%), respectively. for a significant brain injury. This trend of low positive values and high negative values is consistent with other reports.[12,13] Although the predictive values of CCHR were higher than those of NOC for significant brain injury, the difference was not significant in this current study. Both guidelines showed similar positive predictive values of 23% and negative predictive values of NOC - 95% and CCHR - 91%.

High negative predictive values have the tendency to reduce unnecessary CT scans in patients with mild TBI, which is a huge concern for developing countries due to the cost of a CT scan.[14]This is very important as the index study shows very high negative predictive values for the need for neurosurgical intervention, which may not be easily missed when using either of the 2 guidelines in clinical practice at the Accident and Emergency Department or Trauma Centre. Furthermore, the receiver operative characteristics (ROC) curve was used to analyze and compare the diagnostic performances of the NOC and CCHR for clinically significant brain injury against each other and against the reference, which is CT findings, as shown in Figure 2. However, both rules were below the 50% reference mark with an area under the curve (AUC) of 0.45 and 0.42, respectively. This indicates that both NOC and CCHR are weaker in predicting clinically significant brain injury compared to the CT scan, which is the gold standard (reference), despite their usefulness in clinical practice. Whereas this finding may suggest weakness in the decision rules, it should be noted that the rules are merely guidelines themselves and not absolute, as the gold standard (CT scan) is the final arbiter of diagnosis in this scenario. The rules can still play their role in reducing cost and radiation hazard in health systems with poor resources, as in our region. In addition, there is reason to suggest that sample size, methodology and knowledge of the guidelines could influence the results reported from different studies.

Comparison with Contemporary Literature.

These findings are consistent with similar studies comparing the two decision rules.[15] This study has some differences with that of Lo et al in Hong Kong, who reported that the negative predictive values of NOC and CCHR for clinically significant brain injury were 91% and 88%, respectively and that for the need for neurosurgical intervention, 100% and 99%, respectively. [16]These differences in outcome with related studies could be attributable to differences in our health systems and the sample size of the studies. Our findings align closely with modern international validation studies. In a large multicenter cohort study across Europe, Foks et al. reported sensitivities exceeding 99% for both rules, with the CCHR demonstrating significantly higher specificity and greater CT reduction potential.[8] Similarly, Papa et al. confirmed that while both tools reliably identify intracranial injury, the CCHR offers superior discrimination for clinically important brain injury and neurosurgical intervention.[9] International validations from Asia, North Africa, and Europe have shown consistent performance across diverse populations, including studies from Japan, Hong Kong, Tunisia, the Netherlands, and the United Kingdom.[8,11,17]

Clinical Policy and CT Stewardship Implications.

The importance of selective imaging is increasingly emphasized in modern emergency medicine. The 2020 ACEP Clinical Policy explicitly recommends the use of validated clinical decision rules to guide CT utilization in adult mTBI, citing strong evidence for safety and cost-effectiveness.[10] Imaging stewardship initiatives have demonstrated that structured implementation of the CCHR can reduce CT usage by 20–40% without increasing missed injuries or adverse outcomes.[10]

In LMIC contexts, such reductions translate into meaningful improvements in patient flow, affordability, and radiation safety. Given Nigeria's high trauma burden with very high rates of road traffic accidents (fig. 1) and limited imaging infrastructure, the routine application of the CCHR or NOC could significantly optimize resource allocation.

Relevance to Low- and Middle-Income Countries.

While most validation studies originate from high-income countries, emerging data from Africa and other LMICs suggest comparable performance.[18,19] However, barriers to implementation include limited awareness, inconsistent documentation, and medicolegal concerns. Embedding decision rules into institutional protocols, emergency department training, and audit systems may improve adherence and sustainability.

In Nigeria, where a CT scan is mostly an out-of-pocket expenditure, using clinical decision tools like the ones compared can be very helpful, especially in rural areas where the services may not even be available and would require patient transportation to larger cities with the attendant cost and inconvenience to both patient and relatives.

Limitation

The selection criteria of the index study did not include all patients due to the cost of a CT scan that was not fully covered by insurance. In addition, this was a single-center study with a modest sample size. Long-term follow-up of discharged patients was not performed, which may have underestimated delayed intracranial complications. Nonetheless, the findings are consistent with large contemporary datasets and support external validity.

Conclusion

Contemporary evidence supports the continued use of both the Canadian CT Head Rule and New Orleans Criteria in the evaluation of mild traumatic brain injury. In this Nigerian cohort, the CCHR demonstrated higher predictive values, but these were not statistically significant, demonstrating the diagnostic safety of both tools. Integration of validated decision rules into routine emergency practice represents an effective strategy for CT stewardship, particularly in resource-limited settings.

Acknowledgements

All Resident Doctors and House Officers of the Trauma and Neurosurgery Units at the Trauma Centre.

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