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Original Research Article

Comparison of the New Orleans Criteria, NICE Guideline and Canadian CT Head Rule for Cranial Computed Tomography in Minor Head Injury: A Cross sectional Study

Prabhakar Pratik[1], Nishant Sahu[2], Manish Badkur[3], Raghvendra Sadh[4]

[1]Junior Resident, Department of Emergency Medicine, L.N. Medical College and Research Centre, Bhopal, M.P., India

[2]Assistant Professor, Department of Emergency Medicine, Bhopal, M.P., India

[3]Associate Professor, Department of Emergency Medicine, Bhopal, M.P., India

[4]Professor & Head of Department, Department of Emergency Medicine, Bhopal, M.P., India

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Corresponding author: Dr. Prabhakar Pratik

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Abstract

Background and Aims: Computed tomography (CT) is over-used in minor head injury (MHI), exposing many patients to radiation for a low diagnostic yield. We compared the diagnostic performance of the New Orleans Criteria (NOC), the National Institute for Health and Care Excellence (NICE) guideline and the Canadian CT Head Rule (CCHR) against CT in adults with MHI in an Indian emergency department (ED).

Material and Methods: In this observational study, 134 adults (Glasgow Coma Scale 13-15) undergoing non-contrast CT of the head were assessed with all three rules, with CT as the reference standard. Continuous variables were tested for normality (Shapiro-Wilk) and compared with the Mann-Whitney U test; categorical associations used the chi-square or Fisher exact test. Sensitivity, specificity, predictive values and accuracy were computed with 95% confidence intervals, and rules were compared using the McNemar test.

Results: CT was abnormal in 21 patients (15.7%); all were male ($P < 0.001$). NOC was fully sensitive (100%) but poorly specific (4.4%). NICE offered the best balance, with sensitivity 95.2%, specificity 52.2%, negative predictive value 98.3% and accuracy 59.0%, and the strongest association with an abnormal CT (odds ratio 21.85). CCHR was intermediate (specificity 29.2%). NICE could have safely avoided 44.8% of scans, versus 25.4% (CCHR) and 3.7% (NOC); no rule missed a patient requiring neurosurgery.

Conclusion: All three rules were highly sensitive, but the NICE guideline provided the best balance between safety and CT reduction, making it the most suitable rule for resource-conscious Indian EDs.

Keywords: Canadian CT Head Rule; computed tomography; emergency department; minor head injury; NICE guideline; New Orleans Criteria.

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Introduction

Traumatic brain injury is a leading cause of death and disability worldwide, and the overwhelming majority of patients who reach the emergency department (ED) have injuries classified as minor.[1] Minor head injury (MHI) is conventionally defined by a Glasgow Coma Scale (GCS) score of 13 to 15 after blunt trauma, frequently accompanied by brief loss of consciousness, amnesia or vomiting.[2,3]

In India, where road-traffic crashes remain the dominant mechanism, such patients present in large numbers and are commonly referred for computed tomography (CT) of the head.[4] CT is fast, widely available and highly sensitive for surgically important lesions, and this has encouraged its almost reflexive use. Yet most scans performed for MHI are normal, and recent meta-analyses estimate that a substantial share of head CTs are potentially avoidable.[5,6,28] Over-imaging carries real costs, including ionising-radiation exposure, crowding, expenditure and incidental findings, that fall especially heavily on younger patients and on health systems with limited resources.

To make CT ordering more selective, several clinical decision rules have been derived and validated. The New Orleans Criteria (NOC) apply to patients with a GCS of 15 and were designed for very high sensitivity.[7] The Canadian CT Head Rule (CCHR) targets clinically important injury and the need for neurosurgical intervention in patients with a GCS of 13 to 15.[8] The NICE head-injury guideline combines high-risk clinical features into a pragmatic imaging pathway used widely in the United Kingdom and beyond.[9,10] Although these tools perform well where they were developed, their comparative behaviour in Indian EDs, where case mix, referral patterns and scanning thresholds differ, remains insufficiently characterised.[11,12] We therefore compared the diagnostic performance of the NOC, NICE and CCHR against CT as the reference standard in adults presenting with MHI to a tertiary-care Indian ED, with particular attention to how many scans each rule could safely avoid.

Materials and Methods

This observational study was conducted in the Department of Emergency Medicine of a tertiary-care teaching hospital in central India after institutional ethics committee approval and written informed consent. Consecutive adults presenting with head injury were screened for eligibility. Patients aged 18 years or older with MHI (GCS 13 to 15) who underwent non-contrast CT of the head were included. Those with penetrating trauma, a GCS below 13, haemodynamic instability or incomplete records were excluded. Demographic details, mechanism of injury, GCS at presentation and at two hours, vital signs and the clinical variables required by each rule were recorded on a structured proforma. Each patient was independently classified as positive (CT advised) or negative by the NOC, NICE and CCHR.[7,8,9]

All patients underwent non-contrast CT, reported by a radiologist blinded to the rule classifications. A positive CT was defined as any acute traumatic intracranial finding, such as contusion, extradural or subdural haematoma or subarachnoid haemorrhage, or a skull fracture. Disposition, need for neurosurgical intervention and length of hospital stay were recorded. Data were analysed using SPSS V27. Continuous variables were tested for normality with the Shapiro-Wilk test; as all were non-normally distributed, they are summarised as median (interquartile range, IQR) and compared between CT-positive and CT-negative groups using the Mann-Whitney U test. Categorical variables are presented as frequencies and compared using the chi-square or Fisher exact test. For each rule, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy were calculated against CT, with 95% Wilson confidence intervals (CI). The proportion of scans potentially avoidable, termed CT reduction, was derived from each rule's negative fraction. Pairwise differences in rule positivity were assessed with the McNemar test. A two-sided P value below 0.05 was considered statistically significant.

Results

A total of 134 adults were analysed. The median age was 29.5 years (IQR 23 to 40) and 96 (71.6%) were male. Road-traffic accidents were the commonest mechanism (76; 56.7%), followed by falls from height (30; 22.4%). CT was abnormal in 21 patients (15.7%) [Table 1].

All 21 CT-positive patients were male, giving a male positivity of 21.9% versus 0% in females ($P < 0.001$). A lower GCS at two hours (median 14 versus 15; $P = 0.004$) and a lower diastolic blood pressure ($P = 0.033$) were associated with an abnormal scan, whereas age, other vital signs and mechanism of injury were not [Table 1]. Among individual clinical features, open, depressed and basal skull-fracture signs were invariably associated with a positive CT (100%), followed by focal neurological deficit (66.7%), vomiting of two or more episodes (55.6%), seizure (50.0%) and amnesia of at least 30 minutes (42.9%); isolated headache was not predictive ($P = 0.80$) [Table 3].

Among the 21 abnormal scans, cerebral contusion, acute subdural haematoma, extradural haematoma and linear skull fracture were the commonest lesions (four each; 19.0%). Overall, 113 patients (84.3%) were discharged from the ED, 12 (9.0%) were admitted to the ward and 9 (6.7%) to intensive care, and four patients (3.0%) required neurosurgical intervention.

NOC was completely sensitive (100%, 95% CI 84.5 to 100) but had very low specificity (4.4%, 95% CI 1.9 to 9.9). NICE achieved a sensitivity of 95.2% (95% CI 77.3 to 99.2) together with the highest specificity (52.2%), NPV (98.3%) and accuracy (59.0%); CCHR was intermediate, with 95.2% sensitivity and 29.2% specificity [Table 2, Figure 1]. On Fisher exact testing, NICE showed the strongest association with an abnormal CT (odds ratio 21.85; $P < 0.001$), followed by CCHR (odds ratio 8.25; $P = 0.015$). NICE and CCHR each misclassified one CT-positive patient, both minor contusions managed conservatively, while NOC missed none. All three rules retained 100% sensitivity and NPV for patients requiring neurosurgical intervention.

Applied prospectively, NOC would have recommended CT in 96.3% of patients, CCHR in 74.6% and NICE in 55.2%. This corresponds to a potential reduction in scanning of 44.8% with NICE, 25.4% with CCHR and only 3.7% with NOC, against an actual abnormal-CT rate of 15.7% [Figure 2]. Pairwise comparison confirmed that the rules differed significantly in how often they returned a positive result (McNemar $P < 0.001$ for all pairs) [Table 2].

Table 1: Baseline characteristics of 134 patients with minor head injury, overall and by CT result.

Variable	Overall (N=134)	CT-positive (n=21)	CT-negative (n=113)	P value
Age, years, median (IQR)	29.5 (23-40)	27 (25-35)	30 (23-41)	0.350
Male sex, n (%)	96 (71.6)	21 (100)	75 (66.4)	**<0.001**
Mechanism of injury, n (%)				0.580
Road-traffic accident	76 (56.7)	12 (57.1)	64 (56.6)	
Fall from height	30 (22.4)	6 (28.6)	24 (21.2)	
Assault	18 (13.4)	1 (4.8)	17 (15.0)	
Sports / other	10 (7.5)	2 (9.5)	8 (7.1)	
GCS at presentation, median (IQR)	15 (14-15)	15 (14-15)	15 (14-15)	0.237
GCS at 2 hours, median (IQR)	15 (14-15)	14 (14-14)	15 (14-15)	**0.004**
Systolic BP, mmHg, median (IQR)	128.5 (115-146)	123 (115-135)	129 (115-147)	0.563
Diastolic BP, mmHg, median (IQR)	81 (67-89)	69 (65-86)	81 (69-90)	**0.033**

Continuous variables are non-normally distributed (Shapiro-Wilk $P<0.05$) and compared with the Mann-Whitney U test; categorical variables compared with the chi-square or Fisher exact test. BP, blood pressure; GCS, Glasgow Coma Scale; IQR, interquartile range.

Table 2: Diagnostic performance of the three decision rules against CT (reference standard) and potential impact on CT utilisation.

Rule	TP/FP/FN/TN	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	Accuracy % (95% CI)	CT scans advised %	CT reduction %
NOC	21/108/0/5	100 (84.5-100)	4.4 (1.9-9.9)	16.3 (10.9-23.6)	19.4 (13.6-26.9)	96.3	3.7
NICE	20/54/1/59	95.2 (77.3-99.2)	52.2 (43.1-61.2)	27.0 (18.2-38.1)	59.0 (50.5-66.9)	55.2	44.8
CCHR	20/80/1/33	95.2 (77.3-99.2)	29.2 (21.6-38.2)	20.0 (13.3-28.9)	39.6 (31.7-48.0)	74.6	25.4

Negative predictive value: NOC 100% (95% CI 56.6-100), NICE 98.3% (91.1-99.7), CCHR 97.1% (85.1-99.5). Confidence intervals are Wilson score intervals. Pairwise differences in rule positivity were significant on the McNemar test ($P<0.001$ for all comparisons). CCHR, Canadian CT Head Rule; CI, confidence interval; FN, false negative; FP, false positive; NICE, National Institute for Health and Care Excellence; NOC, New Orleans Criteria; PPV, positive predictive value; TN, true negative; TP, true positive.

Table 3: Association of individual clinical features with an abnormal CT.

Clinical feature	Patients with feature, n	Abnormal CT within feature, n (%)	P value
Open / depressed skull fracture signs	7	7 (100)	**<0.001**
Basal skull fracture signs	6	6 (100)	**<0.001**
Focal neurological deficit	12	8 (66.7)	**<0.001**
Vomiting >=2 episodes	9	5 (55.6)	**0.005**
Seizure	8	4 (50.0)	**0.021**
Amnesia >=30 minutes	21	9 (42.9)	**<0.001**
Loss of consciousness	60	16 (26.7)	**0.002**
Headache	89	15 (16.9)	0.802

Associations tested with the Fisher exact test. Denominators indicate the number of patients in whom the feature was present.

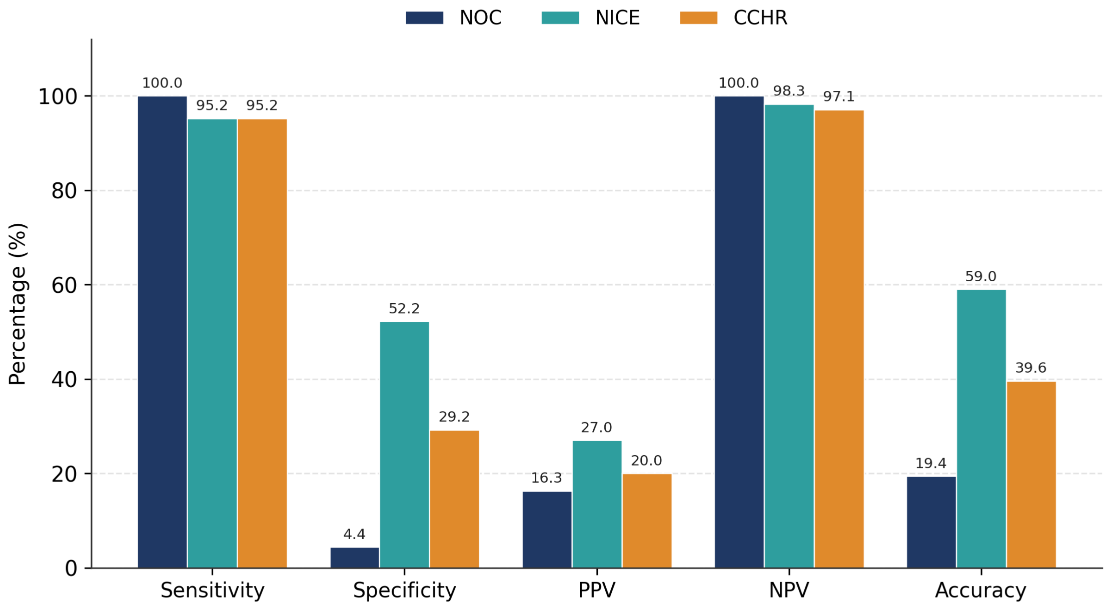

Figure 1: Diagnostic performance of the three decision rules against CT.

NOC, New Orleans Criteria; NICE, National Institute for Health and Care Excellence guideline; CCHR, Canadian CT Head Rule; PPV, positive predictive value; NPV, negative predictive value.

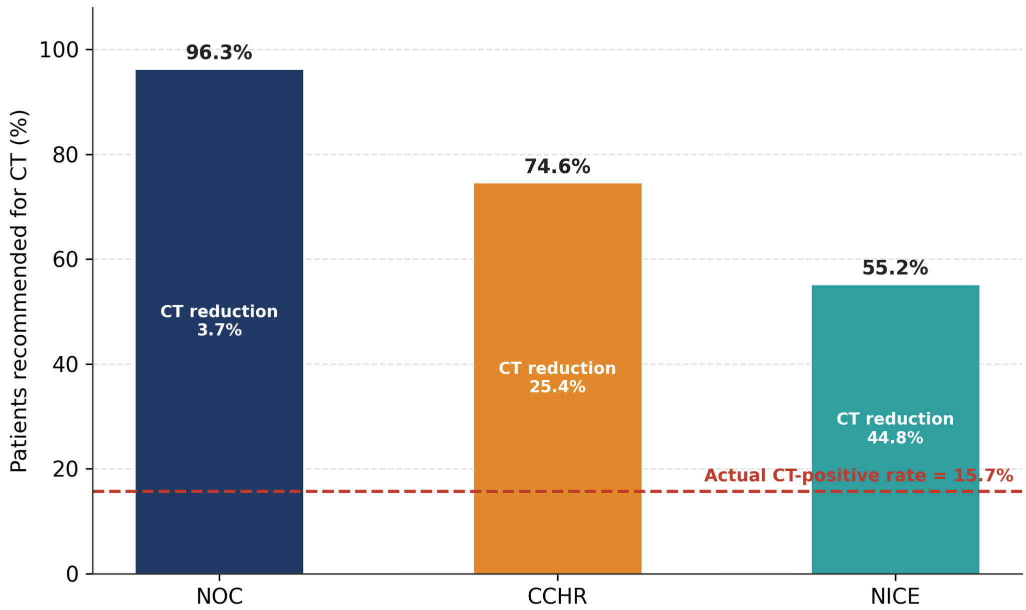

Figure 2: Proportion of patients advised to undergo CT under each rule and the corresponding CT-reduction potential.

Values within each bar indicate the potential reduction in CT scanning. The dashed line marks the observed abnormal-CT rate (15.7%).

Discussion

In this cohort of adults with MHI, all three decision rules were highly sensitive for an abnormal CT, but they diverged sharply in specificity and therefore in their capacity to reduce unnecessary scanning. The NOC identified every abnormal scan yet flagged almost the entire cohort for imaging, whereas the NICE guideline preserved high sensitivity while safely sparing nearly half of the scans. The CCHR occupied an intermediate position. These findings echo the pivotal head-to-head comparison by Stiell and colleagues, in which both the CCHR and NOC were fully sensitive but the CCHR was substantially more specific, and they extend that message to a South-Asian ED where the balance tips towards NICE.[13] The behaviour of the NOC is consistent with its origins: it was derived to identify all abnormal scans in patients with a GCS of 15 and deliberately favours sensitivity over specificity.[7] External validations have repeatedly reproduced this pattern of near-perfect sensitivity with low specificity.[14,15] In our data the NOC would have reduced scanning by less than 4%, which limits its practical value as a rationing tool even though it is reassuringly safe.

The strong performance of the NICE pathway agrees with European work showing that NICE-based imaging can materially reduce CT use without missing important injuries.[16,17] Its combination of high-risk criteria, namely a GCS below 15 at two hours, suspected skull fracture, focal deficit, post-traumatic seizure and repeated vomiting, maps closely onto the very features that were most strongly associated with an abnormal scan in our cohort. That concordance probably explains why NICE achieved both the highest accuracy and the strongest association with an abnormal CT.

The CCHR, designed to detect clinically important injury and the need for neurosurgery, again proved highly sensitive but only moderately specific in our setting.[8] Indian and other low- and middle-income-country validations have reported comparable results, with CCHR sensitivity remaining high while specificity varies with case mix and scanning thresholds.[18,19] A meta-analysis pooling international data similarly found the CCHR to be consistently sensitive with better specificity than the NOC, and a United States trauma-centre study confirmed high sensitivity for traumatic intracranial injury.[20,24] Our finding that CCHR would avoid a quarter of scans, versus the near-half avoided by NICE, reflects the broader, more cautious net that the CCHR casts once its medium-risk criteria are included.

Two clinical observations deserve emphasis. First, every abnormal scan occurred in a male patient, and road-traffic crashes dominated the mechanism profile, a pattern that mirrors the epidemiology of trauma in India, where young men bear a disproportionate share of head injury.[4] Second, the features classically regarded as red flags, including skull-fracture signs, focal deficit, GCS below 15, repeated vomiting, seizure and prolonged amnesia, were strongly predictive, whereas isolated headache was not. This supports the emphasis all three rules place on objective neurological and skull findings rather than on symptoms alone, and reinforces earlier reports identifying similar predictors of an abnormal scan.[21,22]

From a health-systems perspective, the most consequential result is the gap between the abnormal-CT rate of 15.7% and the scanning rate each rule would generate. Universal or NOC-driven imaging would scan nearly everyone to find one abnormal study in six, whereas NICE would approach the problem far more efficiently while still capturing every surgical case. In a country where CT capacity, radiologist availability and out-of-pocket costs are pressing constraints, and where cumulative radiation exposure in young patients is a genuine concern, a rule that halves imaging without sacrificing safety has clear appeal.[5,23] Importantly, no rule missed a patient who required neurosurgery, so the small number of injuries missed by NICE and CCHR did not translate into clinical harm.

These results should be read as complementary to, rather than a replacement for, clinical judgement. Decision rules are designed to be sensitive screening tools, and their modest specificity is an intentional trade-off; the physician's task is to apply them within the local context of resources, follow-up reliability and patient expectations. Our data suggest that, for an Indian ED, embedding the NICE pathway into triage could rationalise CT use while maintaining a safety margin, an approach that could be strengthened by prospective, multicentre evaluation and by implementation strategies shown to change ordering behaviour.[25,27]

Limitations

This study has limitations. It was conducted at a single centre with a modest sample, and only 21 patients had an abnormal CT; the resulting wide confidence intervals mean the specificity and predictive-value estimates should be interpreted cautiously. Because every participant underwent CT, the design cannot capture patients who were clinically judged not to need imaging, and the rules were applied to an already-scanned population rather than at the point of the imaging decision. The reference standard was the initial CT, so small or delayed lesions could theoretically have been missed. Finally, the predominance of road-traffic trauma and young men may limit generalisability to elderly or anticoagulated populations, in whom decision rules behave differently.[26] Multicentre, prospective studies that apply the rules before scanning are needed to confirm these findings.

Conclusion

In adults presenting to an Indian emergency department with minor head injury, the New Orleans Criteria, NICE guideline and Canadian CT Head Rule were all highly sensitive for an abnormal CT and, crucially, for the need for neurosurgical intervention.

The three rules differed most in specificity: the NICE guideline offered the best balance between diagnostic safety and a meaningful reduction in CT use, potentially avoiding almost half of all scans, while the NOC, though completely sensitive, was too non-selective to curb imaging. Adopting the NICE pathway may help rationalise head CT in resource-limited emergency settings without compromising patient safety, and merits prospective multicentre validation.

Ethics, Consent and Declarations: The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants or their legally authorised representatives. The authors declare no conflicts of interest and no external funding.

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