

Original Research Article

APPLICABILITY OF THE CANADIAN CT HEAD RULE IN HEAD TRAUMA MANAGEMENT: A RETROSPECTIVE OBSERVATIONAL STUDY

Rajan Babu¹, Parthasarathy², G Baskaran³, Kirthiga Devi³, Harshada Senthilkumar⁴

¹Final year Post Graduate, Government Villupuram Medical College and hospital, Vikkaravandi, Viluppuram, Tamil Nadu, India

²Associate Professor, Government Villupuram Medical College and hospital, Vikkaravandi, Viluppuram, Tamil Nadu, India

³Assistant Professor, Government Villupuram Medical College and hospital, Vikkaravandi, Viluppuram, Tamil Nadu, India

⁴Undergraduate, Government Villupuram Medical College and hospital, Vikkaravandi, Viluppuram, Tamil Nadu, India

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Corresponding Author:

Dr. Rajan Babu

Final year post graduate, Government Villupuram Medical College and hospital, Vikkaravandi, Viluppuram, Tamil Nadu, India
Email: rajanb254@gmail.com

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ABSTRACT

Background: Head injury is a common presentation to emergency departments worldwide. Computed tomography (CT) of the head is the imaging modality of choice but carries risks of radiation exposure and resource implications. The Canadian CT Head Rule (CCHR) is a validated clinical decision tool designed to rationalise CT use in adults with minor head injury. Despite its validation, real-world application remains inconsistent. The objective is to determine the proportion of head injury patients who underwent CT scanning; (2) to assess adherence to the CCHR; (3) to estimate the potential reduction in unnecessary CT scans if the CCHR is strictly applied.

Materials and Methods: A retrospective observational study was conducted among 74 patients presenting with head injury for a duration of 12 months at Government Villupuram Medical College and Hospital. CCHR applicability was assessed for all patients.

Results: CT scanning was performed in 72 of 74 patients (97.3%). Of these, 34 (47.2%) had abnormal findings. The CCHR was applicable to 48 patients (64.9%) who met the mild head injury definition. Among these, adherence to the CCHR was 89.6% (43/48). The CCHR demonstrated a sensitivity of 93.1%, specificity of 15.8%.

Conclusion: Cranial CT scanning is performed at a very high baseline rate at this institution. Strict adherence to the Canadian CT Head Rule has the clinical potential to safely reduce overall CT utilization by approximately 40% - primarily by filtering out patients who do not qualify as mild head injuries or fall into low-risk strata—thereby conserving resource allocation and minimizing radiation exposure without compromising diagnostic sensitivity.

Keywords: Canadian CT Head Rule; Head Injury; CT utilisation; Clinical decision rule; Emergemedicine.

INTRODUCTION

Traumatic brain injury (TBI) can be considered as the combination of primary injury sustained on impact, and hence not medically modifiable, and secondary injury developing in the following hours and days.^[1] It is recognized by the World Health Organization as one of the leading causes of death and disability worldwide with the global prevalence estimated to be 939 instances per 100,000 individuals, with approximately 5.48 million people per year experiencing severe traumatic brain injury.^[2]

It is classified based on the Glasgow Coma Scale which evaluates three aspects of responsiveness- eye opening, verbal, motor responses with a maximum score of 4, 5 and 6 each respectively. Head injury is classified,^[1] as

- Minor: GCS score of 15 with no loss of consciousness
- Mild: GCS of 13 - 15 with loss of consciousness
- Moderate: GCS of 9 - 13
- Severe: GCS of 3 - 8

India bears one of the highest TBI burdens, largely due to road traffic accidents, with 60% of head

injuries attributable to such incidents.^[3] Road traffic accidents are the leading cause of death for children and young adults aged 5 - 29 years, among which more than 90 % occur in low and middle income countries. In India there were 513,563 accidents in 2025; In Tamil Nadu in 2025 up to the month of June, there were 34,611 accidents.^[3-14]

This highlights the increasing demand for computed tomography scans in healthcare facilities across the country. As a developing nation, not all institutions have access to advanced imaging techniques, necessitating referrals to higher centers. Consequently, it is imperative to ensure the efficient utilization of available resources.

The use of radiation in CT scans warrants careful consideration.^[8] Among the various imaging modalities, X-rays and CT scans are most frequently employed. A critical distinction lies in their radiation dosage: X-rays typically administer 0.01 - 0.1 mSv, whereas CT scans deliver 2 - 20 mSv,^[11] contingent on the anatomical region. For example, a CT scan of the abdomen and pelvis is equivalent to approximately 500 chest X-rays.

Computed tomography (CT) scan of the head is used for the rapid and reliable diagnosis of neurocranial pathologies such as skull fractures, epidural hematomas, and contusions that have occurred secondary to trauma. Many clinical guidelines have been devised and evaluated through the years, such as the New Orleans Criterion, NICE guidelines and the Canadian CT Head Rule.^[8,10,12]

Developed by Dr. Ian Stiell in 2001, it has been the subject of several studies across the decades, used to identify the prevalence of overuse of CT scans,^[4] as well as in diverse clinical settings where it serves to optimize resource allocation by stratifying patients based on clinical risk factors. It has been validated in multiple international settings and provides a structured clinical decision framework to guide CT use in adults with mild head injury.^[12,13,15]

Designed exclusively for patients with mild head injury defined as loss of consciousness, definite amnesia or witnessed disorientation and a GCS score of 13 - 15, a CT is indicated if any one of the risk factors is present.

The rule consists of five high-risk factors (GCS less than 15 at 2 hours after injury, More than 2 episodes of Vomiting, Signs of Basal Skull Fracture, Signs of open/depressed fracture, Age more than or equal to 65 years) and two medium-risk factors (Amnesia before impact for more than 30 minutes, Dangerous mechanism). Signs of Basal skull fracture are considered to be CSF otorrhea, CSF rhinorrhea, hemotympanum, battle's sign or raccoon eyes. Dangerous mechanism includes pedestrian struck by a vehicle and ejection from vehicle, fall from elevation of more than 3 feet or 5 stairs. These guidelines do not apply to patients less than 16 years of age, on anticoagulants, obvious open fracture and non-trauma cases.

While the Canadian CT Head Rule demonstrates a sensitivity of 100% for identifying patients who

require neurosurgical intervention^[5], its clinical utility is frequently constrained by relatively low specificity, which can lead to over-investigation.

Some clinical and patient risk indicators, such as age, consciousness impairment, focal neurological deficit, and time interval between head trauma and CT imaging, can be used as a source of valuable information for further investigation.^[4,13]

Given the high volume of minor head injuries presenting to emergency departments, the application of such standardized clinical decision instruments is essential for optimizing diagnostic accuracy while mitigating the risks associated with ionizing radiation.^[6]

REVIEW OF LITERATURE

Traumatic Brain Injury (TBI) remains a significant global health challenge. While Computed Tomography (CT) is the gold standard for diagnosing intracranial pathology, its indiscriminate use leads to unnecessary radiation exposure and increased healthcare costs. This review examines the applicability, efficacy, and compliance with the CCHR across various international and Indian settings.

A study was conducted in Bahrain in 2021 by Al Omran B to identify the prevalence of computed tomography overuse for mild head injury in adults. The study analyzed 486 CT scans and found that 22.6% of the scans were classified as "overuse" (did not meet CCHR criteria). It concluded that adherence to CCHR could significantly reduce unnecessary radiation exposure and healthcare costs without missing significant injuries.

Another study conducted in Pune, Maharashtra in 2021 by the researchers from the department of emergency medicine found the CCHR to have a 100% sensitivity and a specificity of 45.8%, highlighting its utility as a safe screening tool to reduce unnecessary scans in an Indian setting.

The diagnostic utility of CCHR in minor injuries was determined in a study conducted by Punnen CR in Karad, Maharashtra in 2026. The study reported a sensitivity of 68% and a specificity of 42.5% for the CCHR.

The efficacy of the CCHR was evaluated in Pushpagiri Medical College and Hospital, Kerala in 2024, a study conducted by Reddy A. The study found a sensitivity of 68.4% and a specificity of 42.5%.

The accuracy of Canadian CT Head Rule in Predicting Positive Findings on CT of the Head of Patients After Mild Head Injury was determined in a retrospective study in Saudi Arabia in 2015 by Arab AF et al. The study revealed a high rate of unnecessary imaging, with 61.8% of scans deemed unjustified according to the CCHR. The rule showed a sensitivity of 66.7% and a specificity of 39.1%.

Several aspects of the Canadian CT Head Rule have been evaluated, such as the diagnostic utility, accuracy, and efficacy.

By analyzing local data, the proposed study can bridge the gap between international protocols and local reality, determining whether the CCHR can be safely implemented to optimize resource allocation without compromising patient safety.

Aim

- To assess whether CT scans are being underused or overused and to determine the extent of adherence to clinical guidelines

Objectives

- To determine the proportion of head injury patients who underwent CT scanning during the study period
- To determine the extent of adherence to the Canadian Head CT Rule
- To estimate the potential reduction in unnecessary or missed CT scans if CCHR is applied

MATERIALS AND METHODS

This retrospective observational study was conducted at Government Villupuram Medical College and Hospital over a 12-month period.

Existing medical records were reviewed and eligible participants were identified based on the inclusion and exclusion criteria.

Study population and Inclusion criteria

All adult patients defined as above 18 years of age who presented to the hospital with complaints of head injury in the past 24 hours were considered.

The Canadian CT Head Rule was applied to cases of mild head injury defined as loss of consciousness, definite amnesia or witnessed disorientation and a GCS score of 13–15. Cases that the rule did not apply to were kept for analytical purposes.

Exclusion criteria

Patients below 18 years of age, Patients with any known pre-existing condition requiring a CT, Non-trauma cases, Obvious penetrating injury, Prior history of seizure, Anticoagulant use
The CCHR was used as a reference to assess the extent of CT brain overuse.

Sample size: For a retrospective observational study estimating a proportion (e.g., adherence to the canadian head CT), the sample size is estimated by the formula:

$$n = \frac{Z^2 \times p \times (1-p)}{d^2}$$

where:

P is the expected proportion of the attribute under study

d is the absolute precision (margin of error) desired (e.g., 10% = 0.10).

Assuming p=0.77, d=0.10, and Z=1.96:

$$n = \frac{(1.96)^2 \times 0.77 \times (1-0.77)}{(0.10)^2} \approx \frac{2.958032 \times 0.23}{0.01} \approx 68.034$$

Rounding up yields a sample size of 70 participants. To account for potential non-response or incomplete data, we will recruit 5% extra; thus, the target sample size is 74.

Statistical analysis: Agreement between clinician decisions and CCHR recommendations was assessed using McNemar's exact test for paired binary outcomes, applied to the 48 patients meeting the mild head injury definition. Because clinical decisions and CCHR recommendations were derived from the same patients, comparisons were treated as paired rather than independent samples.

This study was approved by the Scientific Research Committee and the Institutional Ethics Committee.

As the study involved only retrospective review of existing medical records, a waiver of individual informed consent was granted by the committee.

RESULTS

Patient Demographics: Of the 74 patients enrolled in this study, a CT scan was taken for 72 of them of which 68.9% (n=51) were male and 31.1% were female (n=23). The age ranged from 18 to 90 years, with a mean age of 42.9 years.

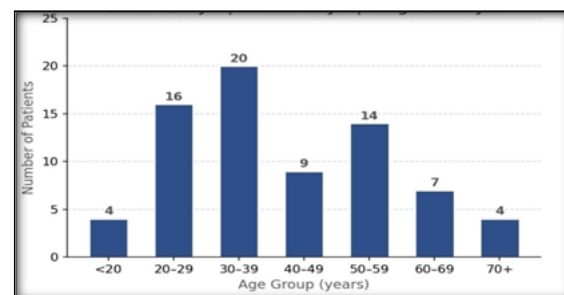


Figure 1: Age distribution of patients (n=74)

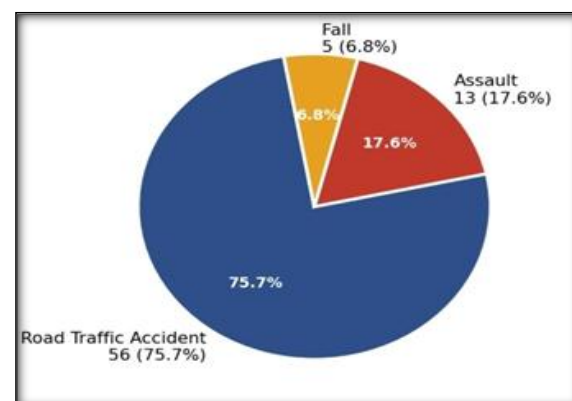


Figure 2: Mechanism of Head Injury(n=74)

Table 1: Patient Demographics - Sex

Sex	n	%
Male	51	68.9%
Female	23	31.1%

Mechanism of Injury: Among the mechanisms of injury RTA was the most common cause accounting for 75.7% of all study participants, followed by assault at 17.6% and lastly, falls.

CT Utilization

Despite only 64.9% (n = 48) meeting the specific inclusion criteria for mild head injury, 97.3%(n=72) underwent CT scanning.

Clinical Presentation: Loss of consciousness was the most prevalent presenting feature, recorded in 45 patients (60.8%), followed by headache in 26 (35.1%), basal skull fracture signs in 12(16.2%), vomiting of any degree in 10 (13.5%) and altered sensorium in 16(21.6%). CSF otorrhea, rhinorrhea, seizures, nausea and amnesia were each present in fewer than 10% of patients.

Table 2: Prevalence of Clinical Features (n = 74)

Clinical Feature	n (of 74)	Prevalence (%)
Loss of consciousness	45	60.8%
Headache	26	35.1%
Basal skull fracture signs	12	16.2%
Vomiting (any episodes)	10	13.5%
CSF Otorrhea	7	9.5%
CSF Rhinorrhea	5	6.8%
Seizures	3	4.1%
Nausea	2	2.7%
Altered sensorium	16	21.6%
Amnesia	1	1.4%

Among the 72 patients who underwent CT scans, 34 (47.2%) exhibited imaging abnormalities, predominantly basal skull fractures, contusions, extradural hematoma, and subarachnoid hemorrhage. The remaining 38 patients (52.7%) presented with unremarkable CT findings.

CCHR Criteria Classification: Of 48 patients presenting with mild head injuries, 17 (35.4%) were categorized as high-risk, 26 (54.1%) as medium-risk, and 5 (10.4%) as low-risk.

Computed Tomography (CT) scans were recommended for all 43 patients identified as high- or medium-risk, constituting 89.5% of the cohort. Among these, 16 patients (37.2%) exhibited normal CT findings.

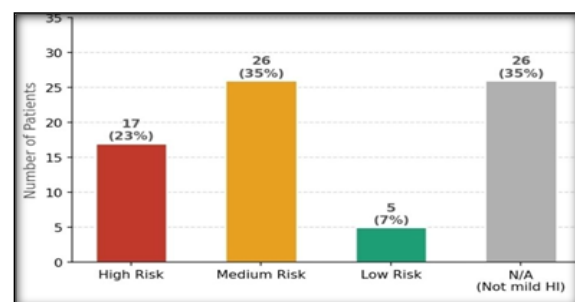


Figure 3: CCHR Classification based on risk criteria

Furthermore, 24 out of 26 patients (92.3%) who did not satisfy the criteria for mild head injury also underwent CT scans; 5 (20.8%) of these revealed CT abnormalities.

CCHR Applicability and Adherence

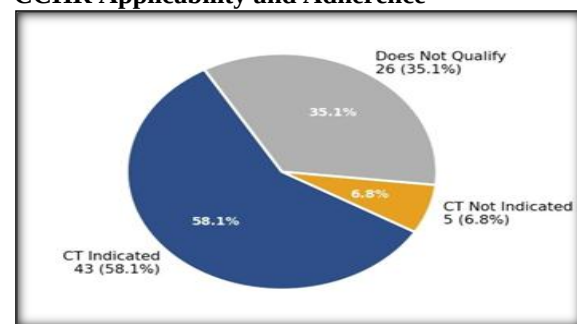


Figure 4: CCHR Classification of all patients

48 patients (64.9%) met the mild head injury definition. Of these, the CCHR recommended CT in 43 (89.6%) and did not recommend CT in 5 (10.4%). The remaining 26 patients (35.1%) did not qualify for CCHR assessment.

Adherence to the CCHR was 89.6% among applicable patients. All five non-adherent cases involved patients in whom the CCHR did not recommend CT but who nonetheless received scanning.

Diagnostic performance of the CCHR: The sensitivity of the test was calculated at 93.1%, while the specificity was observed to be 15.8% among the study population. This is comparable to other studies conducted on the Canadian CT Head Rule, which often report high diagnostic sensitivity but demonstrate variable specificity depending on the clinical setting.

Table 3: Diagnostic Performance 2 x 2 table (n = 74)

	CT Abnormal	CT Normal
CCHR:CT Indicated	27	16
CCHR:CT not Indicated	2	3

Table 4: Diagnostic performance of the CCHR (n = 74)

Sensitivity	93.1
Specificity	15.8
PPV	62.8%

Statistical test of significance: Clinician decisions and CCHR recommendations were discordant in 5 of 48 patients (10.4%), all in the same direction - the clinician ordered a CT that the CCHR did not recommend; no case occurred in which the CCHR recommended a CT the clinician withheld. McNemar's exact test did not show a statistically significant difference between the two decision-makers overall ($p = 0.063$).

DISCUSSION

This study demonstrates a very high CT scanning rate (97.3%) among patients presenting with head injury. Adherence to the Canadian CT Head Rule has been calculated to be 89.6% among the cases that fit the mild head injury definition. There were no instances of a CT indicated by the rule not being performed.

A primary finding of this study is the structural limitation of the CCHR when applied to real-world infrastructure constraints in a developing country. Strictly implemented, the CCHR could have safely prevented approximately 40 % of the scans performed in this cohort (29 out of 72). This comprised 24 scans in patients who did not meet the minor head injury definition, and 5 scans in mild HI patients where the CCHR did not recommend imaging.

This reduction would conserve financial resources and lower ionizing radiation exposure - which remains a key concern given that a standard head CT exposes patients to significantly higher radiation doses than conventional radiography.

35% of the study population did not fall under the definition of mild head injury as defined by the Canadian CT Head Rule. This shows the true proportion of cases for which the rule is applicable; while it can be used for majority of the cases presenting in the emergency department, it does not apply to the entire study population.

The CCHR's "dangerous mechanism" criterion is anchored to road traffic accidents (RTAs) and falls from height; While assault is not an exclusion criterion, it is a source of diagnostic uncertainty in practice. This represents a systematic limitation of the rule in settings where assault constitutes a significant proportion of head injury presentations.

The diagnostic performance of the CCHR in our study cohort - demonstrating a high sensitivity of 93.1 % alongside a remarkably low specificity of 15.8 % - reaffirms its primary utility as a safe clinical screening tool, though it varies from classical literature benchmarks. Stiell et al. demonstrated a 100% sensitivity in his study conducted in 2001. Regional adaptations across diverse clinical settings show mixed outcomes. For instance, Al Omran et al. identified a 22.6 % rate of overt CT overuse in a Middle Eastern adult cohort, while Arab et al. highlighted that 61.8 % of head scans were completely unjustified under strict CCHR application.

There are several limitations to the rule:

- Does not include the whole population of patients presenting with complaints of head injury and GCS 13 - 15.
- Does not include Assault as a criterion - but several cases have had abnormalities in the CT
- RTA is considered a dangerous mechanism thereby classifying the case as a medium risk. In an institute with a high intake of road traffic accidents, the spectrum effect is observed.

This evaluation has several limitations. First, its retrospective nature relies entirely on the accuracy of existing medical records. Second, the single-center design and relatively small sample size ($n = 74$) restrict the generalizability of these findings. Finally, the high volume of road traffic accidents introduces a clear spectrum effect that naturally reduces the specificity of any standardized clinical decision rule.

CONCLUSION

CT head scanning was performed at a high rate in patients presenting with head injury at this institution, with nearly all patients undergoing imaging despite only a proportion fulfilling the criteria for Canadian Head CT Rule criteria. If applied consistently it has the potential to preserve resources and reduce radiation exposure. Further validation is required in a larger, prospective study along with strict compliance to guidelines.

The Canadian CT Head Rule showed high sensitivity in this study, supporting its role as a safe clinical decision tool. At the same time, its low specificity highlights the tendency toward overimaging. Strict adherence to the Canadian CT Head Rule has the potential to reduce CT utilisation by approximately 40%. To achieve a reduction in unnecessary radiation exposure and resource expenditure, it can be recommended that future protocols pair the CCHR with dedicated short-stay clinical observation units. The CCHR is a clinical decision tool that should complement clinical assessment and not completely replace it. Prospective, multi-center domestic validation trials are required to refine these criteria for environments with high rates of road traffic injuries before they can be safely integrated into standard triaging workflows.

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