ORIGINAL ARTICLE

Canadian CT head rule adherence in a rural hospital without in-house computed tomography

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Abstract

Introduction: We sought to determine the difference between Canadian CT Head Rule (CCHR) indicated imaging rates and actual imaging rates for patients with mild traumatic brain injuries (mTBIs) at a rural emergency department (ED) without in-house computed tomography (CT). In addition, we compared CCHR adherence at a hospital without CT to previous publications from centres with CT to determine if rural populations receive less CT imaging for minor head traumas when indicated by the CCHR.

Methods: This retrospective chart review explored individuals who presented to a rural ED (no in-house CT scanner) with a primary diagnosis of mild head injury or concussion between 1 January 2017 and 31 December 2021. Information regarding CCHR criteria, transfer status and patient demographics was collected. Descriptive analyses were completed to determine the percentage of patients who received appropriate transfer for imaging, did not receive transfer for imaging when indicated and received unnecessary transfer.

Results: A total of 124 charts met our inclusion criteria (17 [12.1%] charts excluded), with 25.8% transferred to the nearest hospital for CT imaging. After applying the CCHR criteria to our charts, 62.1% were indicated for CT. Of the 62.1%, only 35.1% were transferred for imaging (51.2% of high-risk and 16.7% of medium-risk).

Conclusion: By exploring CT rates for mTBIs in a rural Canadian ED, we found low transfer rates (35.1%) of CCHR-indicated patients for imaging needed to guide further healthcare decisions. This work highlights a discrepancy within the Canadian healthcare system between rural and urban centres and allows for opportunities to help narrow the gap in health care.

Keywords: Emergency imaging, emergency medicine, head injury, rural medicine

Résumé

Introduction: Nous avons cherché à déterminer la différence entre les taux d'imagerie indiqués par le Canadian CT Head Rule (CCHR, règlement canadien relatif à la tomodensitométrie de la tête) et les taux d'imagerie réels pour les patients souffrant de traumatismes craniocérébraux légers (TCCL) dans un service d'urgence rural ne disposant pas d'une tomographie par ordinateur interne. En outre, nous avons

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comparé l'adhésion au CCHR dans un hôpital sans tomographie par ordinateur à des publications antérieures provenant de centres avec tomographie par ordinateur afin de déterminer si les populations rurales reçoivent moins d'imagerie par tomodensitométrie pour les traumatismes crâniens mineurs lorsque le CCHR l'indique.
Méthodes: Cette étude rétrospective des dossiers a exploré les personnes qui SE sont présentées à une urgence rurale (sans tomodensitomètre interne) avec un diagnostic primaire de traumatisme crânien léger ou de commotion cérébrale entre le 1er janvier 2017 et le 31 décembre 2021. Les informations concernant les critères du CCHR, l'état de transfert et les données démographiques des patients ont été recueillies. Des analyses descriptives ont été réalisées pour déterminer le pourcentage de patients ayant reçu un transfert approprié pour l'imagerie, n'ayant pas reçu de transfert pour l'imagerie quand c'était indiqué et ayant reçu un transfert inutile.
Résultats: Au total, 124 dossiers répondaient à nos critères d'inclusion [17 (12,1%) dossiers exclus], dont 25,8% ont été transférés à l'hôpital le plus proche pour une imagerie par tomodensitométrie. Après avoir appliqué les critères du CCHR à nos dossiers, 62,1% d'entre eux étaient indiqués pour une tomodensitométrie. Sur ces 62,1%, seuls 35,1% ont été transférés pour imagerie (51,2% de haut risque, 16,7% de risque moyen).
Conclusion: En explorant les taux de tomodensitométrie pour les TCCL dans un service d'urgence rural canadien, nous avons constaté de faibles taux de transfert (35,1%) des patients recommandés par le CCRH pour une imagerie nécessaire dans le but de guider les décisions de soins de santé ultérieures. Ce travail met en évidence un écart dans le système de santé canadien entre les centres ruraux et urbains et offre des opportunités pour aider à réduire l'écart dans les soins de santé.

Mots clés: Médecine rurale, Médecine d'urgence, Traumatisme craniocérébral, Imagerie d'urgence

INTRODUCTION

Between 2002 and 2018, more than 5 million emergency department (ED) visits occurred for head injuries in the Canadian provinces of Ontario and Alberta alone.[1] Among patients who visited the emergency department for head injuries, the most common causes were falls in the older population, and sport/recreation-related activities and transportation collisions in adolescents and young adults.[1] To complement clinical acumen and help physicians identify dangerous, potentially life-threatening pathologies associated with head traumas, including vascular, structural and neurological complications, computed tomography (CT) head imaging is commonly used.[2,3] Given the high level of radiation exposure, cost and general burden that CT imaging of mild traumatic brain injuries (mTBIs) has on the healthcare system, multiple guidelines have been developed to help reduce unnecessary imaging.[2-4] One example is the Canadian CT Head Rule (CCHR), which outlines criteria for head CT in mTBI patients and is used in EDs internationally.[4] The high-risk criteria outlined in the CCHR are 100% sensitive and 68.7% specific for predicting the need for neurological intervention.[5] The medium risk criteria have a sensitivity and specificity of 98.4% and 49.6%, respectively, for predicting clinically important pathology.[5] The CCHR is a widely adopted screening tool used in mTBI patients; however, its efficacy in rural communities without CT scanners is unknown.[3,5]

Approximately 20% of Canadians live in rural communities, and 22.5% live over 1 h by car from a Level 1 or 2 trauma centre.[6] Despite the increased prevalence of outdoor recreation and therefore increased risk of mTBI in rural communities, these communities typically have decreased resources and increased barriers to accessing care (e.g. distance and time).[6] In 2014, an estimated 71% of British Columbia's rural and small-town EDs were over 300 km from a Level 1 trauma centre, compared to only 42% in Quebec.[6] Although the number of CT scanners per million people in BC and Quebec is similar (14.0 and 14.8 CT scanners in 2011, respectively), 97% of rural EDs in BC did not have access to 24/7 CT services compared to 27% in Quebec.[6] Given that rural trauma patients take, on average, 6 h more to arrive at Level 1 trauma centres, delayed detection of advanced pathologies has the potential to produce worse outcomes in these patients.[6]

This study aimed to determine if patients in a rural BC region, without accessible CT imaging, received a lower rate of imaging for mTBIs compared to centres with CT. The primary

objective was to evaluate CCHR-indicated imaging rates versus actual imaging rates for patients with mTBI at a rural hospital without in-house CT.

METHODS

Study design and time period

A retrospective chart review was conducted on head injuries between 1 January 2017 and 31 December 2021. With an estimated 25–30 charts per year meeting CCHR inclusion criteria, our sample size was estimated as 125–150 charts over 5 years.

Study setting

This community has a population of <10,000 people (2021 consensus) and is a tourism hub due to its skiing/snowboarding/mountain-biking terrain and its proximity to a major highway.[6] This rural ED serves approximately 9000 patients annually, with the majority between 18 and 44 years old (2021/22 statistics).[7] The nearest CT scanner is located over 100 km away at a Level 2 community hospital.

Population

Our study population included individuals over 16 years old who presented to the rural ED with a primary diagnosis of head injury or concussion. Inclusion criteria included individuals who experienced blunt trauma to the head within 24 h of presenting to the ED resulting in either definite amnesia, witnessed loss of consciousness or disorientation. Individuals must have had a Glasgow Coma Score (GCS) >13 upon ED presentation. Exclusion criteria included obvious penetrating skull injury or depressed skull fracture, acute focal neurological deficits, unstable vitals, seizure before ED assessment, bleeding disorders, anticoagulant use, pregnancy and previous assessment for the same injury.

Outcome measures

Once an ED chart met the initial inclusion criteria, the year of admission, patient age, CCHR information and whether the patient received a transfer for CT imaging were recorded. After data extraction, charts were separated into those with CT indications, based on the CCHR, with no transfer and those who received interfacility transfer for CT imaging.

Data analysis

Descriptive analyses were used to report the percentage of patients who did not receive interfacility transfer for CT imaging when indicated, those who received transfer and those who received unnecessary transfer. CCHR compliance was evaluated by the number of patients who correctly received transfer for CT and those who were correctly not transferred.

Individual patient consent was not required for this study, as no directly identifiable data were collected. Support for this research project was provided by the rural community hospital's Chief of Staff. This study received approval from the Interior Health and University of British Columbia Clinical Research Ethics Boards (REB: H22-00953).

Ethics approval was granted by the University of British Columbia Human Research Ethics Committee (Project H22-00953).

RESULTS

A total of 141 charts with a primary diagnosis of head injury or concussion were reviewed, with 124 charts meeting the inclusion criteria (12.1% excluded). The median age of patients reviewed was 30 years old and 66.1% of patients were male [Table 1]. Of these patients, 25.8% received a transfer to the nearest hospital for a CT scan [Figure 1]. Of the 124 charts reviewed, 62.1% had indications for head CT based on the CCHR. Of these, 35.1% were transferred for imaging (51.2% high-risk charts and 16.7% medium-risk charts) [Figure 2]. The overall compliance with the CCHR criteria was 55.7%. Five patients without CCHR indication for CT were transferred (10.6%), leading to 25.8% of our sample receiving imaging. Specific transfer rates by CCHR criteria met are outlined in Table 2.

DISCUSSION

Interpretation of findings

The Canadian Head CT rule was identified by physician leadership at our study centre as the

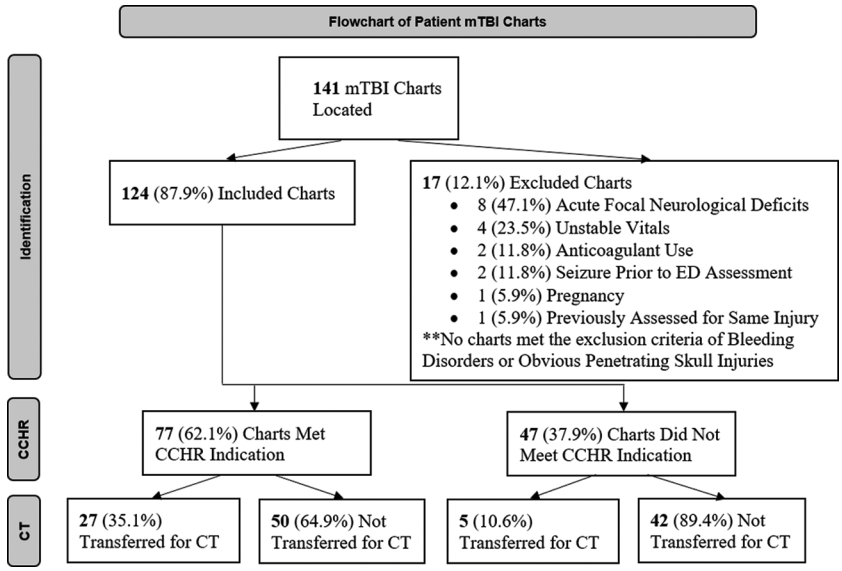

Figure 1: Flowchart of patient mild traumatic brain injury charts. mTBI: Mild traumatic brain injury, CT: Computed tomography, CCHR: Canadian CT head rule, ED: Emergency department.

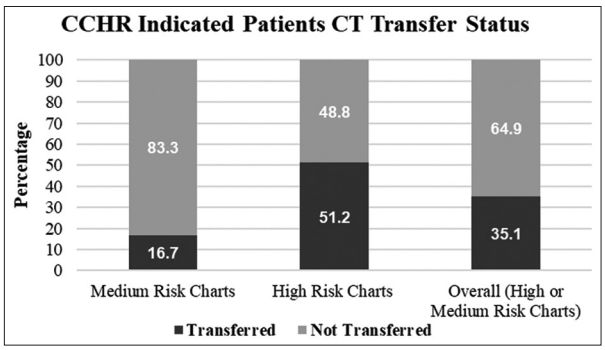

Figure 2: Percentage of Canadian CT head rule indicated patients who received a transfer and those who did not for computed tomography imaging. CT: Computed tomography, CCHR: Canadian CT Head Rule.

standard used to decide which patients require CT imaging of the brain following head trauma. Although this rule was initially created to reduce the amount of unnecessary imaging, based on its high sensitivity and specificity to identify serious neurological pathology associated with mTBI, this tool has been used in previous studies as a marker of appropriate CT rates in mTBI.[5,8] The data collected from this rural Canadian hospital, without in-house CT, demonstrated that only 35.1% of those patients with indication for CT by this standard were transferred when indicated. This underutilisation of the CCHR criteria may be due to multiple factors, including the logistics of organising patient transfer, transfer time, staffing, cost, weather conditions and road closures. In addition, patient-oriented stressors need to be addressed including the burden and risk of transportation, along with shared decision-making including family members that may also need to travel.

Many of these factors could result in local ED physicians foregoing indicated imaging due to difficult access to appropriate resources. This pattern of practice has the potential to delay diagnosis or even miss significant and even life-threatening intracranial pathology. Numerous alternative strategies are utilised in rural and remote communities to mitigate this risk. These include additional time in ED for reassessment, admission to hospital and discharge with instructions to represent for reassessment. These are only a few of the strategies used in rural EDs to mitigate the risk of inadequate imaging. Furthermore, managing these patients with serial clinical examinations or admission, instead of imaging, creates significant delays to discharge and puts an additional burden on an already strained system. Patients who initially meet CT criteria, based on the CCHR, but are not transferred for imaging often require prolonged patient monitoring and follow-up which can further impact the efficiency and workflow of these rural EDs. Although clinical outcomes for the patients reviewed in this study were not assessed, prior publications have provided estimates on the positive predictive value (PPV) of the CCHR in mTBI. Most recently, Kavalci *et al*. reported a PPV of 42% for patients with GCS 13 and an overall PPV of 11.1% in their comparison of the

CCHR and New Orleans Criteria.[9] Analysis of clinical outcomes of mTBI patients presenting to non-CT enabled facilities is a possible area of future research.

Comparison to previous studies

Despite the high sensitivity of the CCHR, facilities with CT on-site report a CCHR compliance rate between 60% and 80%.[3] In these tertiary care centres, CCHR compliance is low due to overutilisation of CT when not indicated by the CCHR; however, only a small proportion of patients do not receive imaging when indicated.[3] With respect to the proportion of patients indicated for head CT, 85.7% received imaging in a 2018 study from Singapore.[3] In Canada specifically, a study out of a large urban hospital in Halifax, Nova Scotia, determined that 86.5% of patients received CT imaging when indicated by the CCHR.[10] Our study found that only 35.1% of patients at this rural, non-CT enabled site were receiving imaging when indicated. A prior study published in 2017 out of Queenstown, New Zealand, whose hospital has no CT on-site, reported transfer for CT in only 23.6% of patients with CCHR recommendations.[8] This Queensland hospital also reports using the CCHR as their standard of care for imaging of mTBI patients.[8] This Queensland study did, however, include skiing/snowboarding and mountain biking in their medium risk criteria as a dangerous mechanism of injury. When our criteria for dangerous mechanisms are expanded to match those used in the New Zealand study, our rate of adherence drops to 31.6%. These findings suggest a large difference in imaging based on CCHR indications between hospitals with and without CT on-site.

Table 1: Characteristics of patient charts

Characteristics	Included charts, *n* (%)	Transferred charts, *n* (%)
Total charts pulled	124	32 (25.8)
Median age (IQR)	30 (25–45)	30 (25–60)
Sex		
Male	82 (66.1)	21 (65.6)
Female	42 (33.9)	11 (34.4)
Charts by year		
2017	20 (16.1)	6 (18.8)
2018	20 (16.1)	3 (9.4)
2019	33 (26.6)	9 (28.1)
2020	27 (21.8)	4 (12.5)
2021	24 (19.4)	10 (31.3)

IQR: Interquartile range

Limitations

Limitations for this study include the potential inability to find and screen all patient charts that should be included in our study. Patients with multiple presenting conditions could be labelled under a different primary diagnosis and therefore missed in our data collection. We were limited by the information included in the patient charts to determine whether patients should have received CT imaging. The reasoning for the lack of patient transfer is also not included in our data, limiting our ability to speculate on why the patient did not receive a transfer. Clinical outcomes of the transferred and non-transferred patients are also not reviewed in this study. Finally, this study

Table 2: Canadian computed tomography head rule criteria

Characteristics	Total, *n* (%)	Transferred, *n* (%)	Not transferred, *n* (%)	Per cent transferred (%)
Only medium-risk criteria				
≥30 min of amnesia	6 (14.6)	2 (25.0)	4 (12.1)	33.3
Dangerous mechanism*	35 (85.4)	6 (75.0)	29 (87.9)	17.1
Total	41	8	33	19.5
Total meeting ≥1 medium-risk criteria	36	6	30	16.7
High-risk criteria**				
Age over 65	15 (31.9)	6 (23.1)	9 (42.9)	40.0
GCS <15 2 h post-injury	24 (51.1)	14 (53.8)	10 (47.6)	58.3
≥2 episodes of vomiting	3 (6.4)	1 (3.8)	2 (9.5)	33.3
Signs of basilar skull fracture	5 (10.6)	5 (19.2)	0	100.0
Total	47	26	21	55.3
Total meeting ≥1 high-risk criteria	41	21	20	51.2

*Dangerous mechanism includes struck by the vehicle, ejected from the vehicle or fall from ≥3 feet or ≥5 stairs, **No patients met the suspected open or depressed skull fracture high-risk criteria. GCS: Glasgow Coma Score

only evaluated one ED in a rural community, so the generalisability of this study may be limited as rural communities often encounter unique healthcare challenges and discrepancies.

Clinical implications

Increasing access to CT imaging in rural health centres is an essential step to decrease the discrepancy in healthcare access between rural and urban patient populations. With many complications of head and brain injuries, including those with higher morbidity and mortality (e.g. hematoma, stroke and fracture), time is valuable. More accessibility to CT scanners would help to mitigate the increased cognitive burden placed on rural emergency physicians, potentially improve health outcomes for patients and decrease patient load on EDs by decreasing the need for prolonged observation, admission and repeat assessment of these patients.

CONCLUSION

By exploring CT rates for mTBI patients in a rural Canadian centre, we found that only 35.1% of patients received transfer for CCHR-indicated injuries. Compliance with the CCHR criteria in this rural centre was much lower than previously reported rates out of urban centres with CT on site. This work highlights the imbalance within the Canadian healthcare system between rural and urban centres and allows for opportunities to help narrow the gap in access to healthcare resources.

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