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BRIEF REPORT OPEN ACCESS

Applying the Canadian Head CT Criteria to Older Adults Seen in the Emergency Department After a Fall

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ABSTRACT

Background: The Canadian CT Head Rule (CCTHR) is validated in adults who hit their head and experience loss of consciousness, amnesia, or disorientation. There is less evidence to guide brain imaging when the fall history is unclear.

Methods: This is a secondary analysis of a prospective study on adults aged ≥65 who presented to 11 emergency departments across Canada and the United States after a ground level fall. We reported the prevalence of adjudicated clinically important intracranial bleeding within 42 days of the emergency department visit among (a) patients who hit their head and met the application criteria for the CCTHR (experienced loss of consciousness, amnesia, or disorientation), (b) patients who hit their head and did not meet the CCTHR application criteria, (c) patients with an unclear history of the CCTHR application criteria, (d) patients with an unclear head injury history, and (e) patients with no head injury.

Results: 4303 participants were analyzed. The prevalence of clinically important intracranial bleeding in the subgroups was (a) patients who fulfilled the CCTHR application criteria, 7.7% (54/703, 95% confidence interval [CI]: 5.9%–9.9%), (b) patients who hit their head but did not meet CCTHR application criteria, 2.5% (30/1204, 95% CI: 1.8%–3.5%), (c) patients with head injury but

an unclear history of the CCTHR application criteria, 7.6% (19/251, 95% CI: 4.9%–12.0%), (d) patients with an unclear history of head injury, 4.6% (23/502, 95% CI: 3.2%–6.8%), and (e) patients who did not hit their head, 0.8% (13/1643, 95% CI: 0.5%–1.3%).
Conclusions: Older adults presenting after a fall with an unclear history of head injury, or an unclear history of head injury-associated loss of consciousness, amnesia, or disorientation have an elevated risk for clinically important intracranial bleeding that merits emergency brain imaging.

1 | Introduction

As our society ages, an increasing number of older adults present to emergency departments after falling, with rates almost doubling in the last two decades [1–3]. Ground-level falls are the most common cause of intracranial bleeding in older adults, and the mortality rate of fall-associated intracranial bleeding is 15% [3–6]. The best-validated evidence-based decision rule for guiding the use of brain imaging for head trauma is the Canadian CT Head Rule (CCTHR) [7]. When the rule was developed and validated, the CCTHR was applied to patients who experienced loss of consciousness, amnesia or disorientation following head injury (we refer to here as the CCTHR application criteria). In 12% of older adults who fall, it is not possible for medical staff to determine whether they hit their head, and in 20%, patients are unable to communicate whether they experienced loss of consciousness, amnesia or disorientation [8]. Current literature is lacking on the need to rule out intracranial bleeding in patients where the history is unclear.

Although only 5% of falls are associated with intracranial bleeding [9], a recent publication highlighted traumatic brain injury as a top missed emergency department diagnosis [10]. There is a tension between avoiding unnecessary brain imaging (sometimes referred to as over testing) [11] and missing a potentially fatal diagnosis like intracranial bleeding. Performing a CT scan on everyone is costly, may necessitate hospital transfer, and prolongs the emergency department stays. Longer stays are associated with increasing delirium risk in older patients [12]. When applied to adults over 65 with a head injury, the CCTHR recommends brain imaging. We lack evidence whether the CCTHR should be applied to (and brain imaging ordered) for older adults who fall when head injury is unclear, or the CCTHR application criteria history is unclear. At present, emergency physicians do not know whether brain imaging can be safely avoided in these patients.

The purpose of this study is to estimate the prevalence of intracranial bleeding in older adults presenting to the emergency department after a ground-level fall when there is an unclear history of head injury or an unclear history of loss of consciousness, amnesia or disorientation following head injury (the CCTHR application criteria).

2 | Methods

2.1 | Study Design and Population

This study is a secondary analysis of a previously conducted prospective cohort study that enrolled 4308 patients between January 30th, 2019 and November 15th, 2020 [13]. The study followed the STROBE reporting guideline [14]. The study was conducted in 11 hospitals in Canada and the United States, enrolling older adults (65 years or older as per the prior World Health Organization definition) who presented to the emergency department within 48 h of a fall [13]. Patients were eligible if they fell from standing on level ground, from a chair, toilet seat, or out of bed. Exclusion criteria are outlined in the study publication [13].

2.2 | Patient Assessment and Follow-Up

Emergency physicians assessed each patient during their index emergency department visit. The decision to order a head CT scan was at the discretion of the treating emergency physician. All patients were followed for 42 days after their initial visit by hospital chart review [8]. All chart-extracted data were validated centrally. Discrepancies were resolved by the site research staff or the site principal investigator.

2.3 | Outcome Definition and Measurement

The primary outcome of this study was "clinically important intracranial bleeding" diagnosed within 42 days of the index emergency department presentation [8]. Patients diagnosed with intracranial bleeding by day 42 were followed for 90 days from the date of diagnosis. Clinically important intracranial bleeding was defined as bleeding within the cranial vault (including epidural, subdural, subarachnoid, intracerebral, or intraventricular hemorrhage, or hemorrhagic cerebral contusion) that required medical or surgical treatment within 90 days or led to death within 90 days of the intracranial bleed diagnosis. "Medical treatment" encompassed any of the following: temporary or permanent discontinuation of anticoagulant or antiplatelet medication, administration of an antifibrinolytic drug, reversal of anticoagulation, hospital admission, or neurosurgical intervention. A centralized independent adjudication committee, consisting of a study neurologist, neurosurgeon, trauma surgeon, and radiologist, reviewed all head CT scans that reported intracranial bleeding to confirm the presence or absence of intracranial bleeding. The committee members were blinded to the baseline history and clinical findings [13].

2.4 | Exposure Measurement

The exposures of interest were head injury on falling, and post-fall loss of consciousness, amnesia or disorientation (referred to as the CCTHR application criteria). The treating physician documented their findings on a study-specific data form, after they had evaluated the patient and prior to the patient undergoing brain imaging (therefore blinded to the presence or absence of intracranial bleeding). Physicians had the option to document these variables as present, absent, or unclear.

Summary

- Key points
  - Patients who present with a fall-related head injury, who have an unclear history of loss of consciousness, amnesia or disorientation have an elevated risk of intracranial bleeding.
  - When it is unclear whether an older adult hit their head during a fall, there is an elevated risk of intracranial bleeding.
  - In an older adult who has fallen and has no history of head trauma, the risk for intracranial bleeding is very low.
- Why does this paper matter?
  - This study determined the prevalence of intracranial bleeding in older adults who fell and cannot give a clear history.
  - Our findings suggest that physicians should consider testing for intracranial bleeding in patients who cannot recall or communicate the events of a fall.

2.5 | Data Analysis

Study patients were classified into 5 subgroups: (a) patients who met the CCTHR application criteria (hit their head on falling and experienced loss of consciousness, amnesia, or disorientation); (b) patients who hit their head but did not meet the CCTHR application criteria (did not experience loss of consciousness, amnesia, or disorientation); (c) patients who hit their head but whose history of the CCTHR application criteria was unclear (history of loss of consciousness, amnesia or disorientation was unclear); (d) patients who had no clear history or examination findings of whether they hit their head; (e) patients who did not hit their head. We calculated the prevalence of clinically important intracranial bleeding among each of the subgroups with Wilson Score 95% confidence intervals (CI). To account for confounding introduced by the clinical use of the CCTHR, we also performed a logistic regression analysis to estimate odds ratios for clinically important intracranial bleeding adjusted for CT head scan use at the index visit.

2.6 | Sample Size

There were 502 patients where a history of head injury was unclear, and 249 patients where the CCTHR application criteria status was unclear. We had a sufficient sample to calculate the 95% CI (Wilson Score method) for the proportion of patients diagnosed with intracranial bleeding ±2% and ±4% respectively, if the prevalence was 8% or lower.

3 | Results

3.1 | Participant Characteristics

There was a total of 4308 older adults presenting to the emergency department after a ground-level fall, five of whom were excluded from this analysis because of missing exposure data (Figure 1). From the 4303 included patients, 2698 (62.6%) had head CT scanning at the index visit. The median age was 83, 64.3% were female, 25.9% were taking anticoagulation, 36.4% were taking an antiplatelet medication. Demographic characteristics and clinical features of the participants in each subgroup are presented in Table 1. Of note, dementia was prevalent (60%) among patients in whom head injury, loss of consciousness, amnesia, or disorientation were unclear.

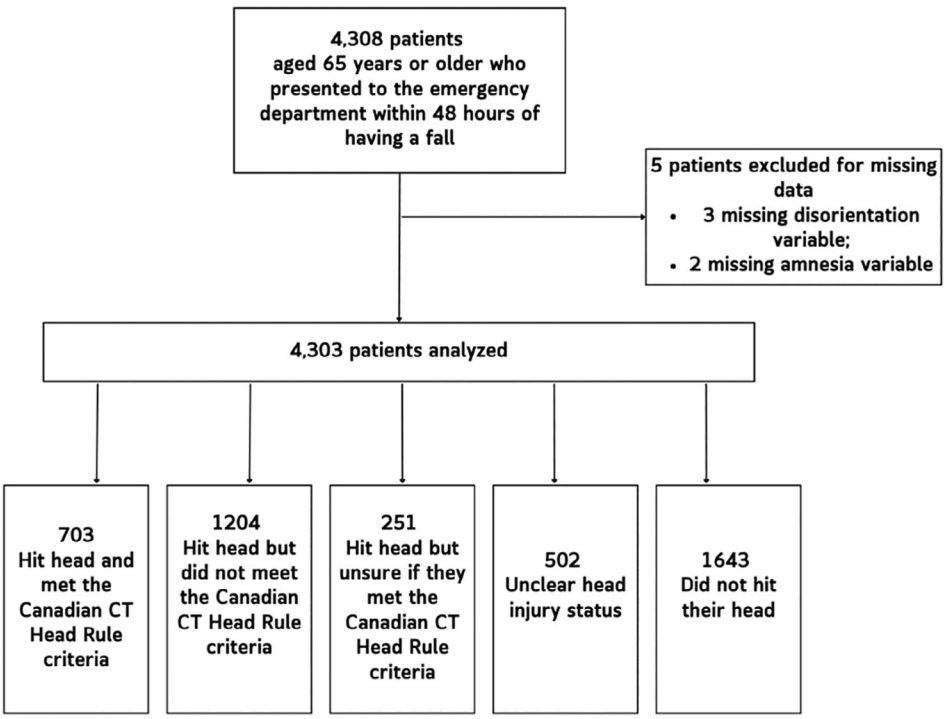

FIGURE 1 | Flow chart for inclusion and group allocation.

TABLE 1 | Demographics of the study cohort and examination findings.

	Number (%) of patients					
	Total	**(a) Hit head and met CCTHR criteria**	**(b) Hit head but did not meet CCTHR criteria**	**(c) Hit head but unclear history of CCTHR criteria**	**(d) Unclear head injury status**	**(e) Did not hit their head**
Category	***N*=4303**	***N*=703**	***N*=1204**	***N*=251**	***N*=502**	***N*=1643**
Age						
Median (IQR)	83 (14.0)	83 (15.0)	83 (13.0)	85 (13.0)	86 (12.0)	81 (14.0)
Sex						
Female	2766 (64.3)	415 (59.0)	798 (66.3)	165 (65.7)	332 (66.1)	1056 (64.3)
Medical history						
Major bleeding	87 (2.0)	9 (1.3)	22 (1.8)	5 (2.0)	18 (3.6)	33 (2.0)
Stroke/TIA	759 (17.6)	144 (20.5)	195 (16.2)	53 (21.1)	95 (18.9)	272 (16.6)
Congestive heart failure	509 (11.8)	77 (11.0)	139 (11.5)	33 (13.1)	79 (15.7)	181 (11.0)
Hypertension	3116 (72.4)	511 (72.7)	877 (72.8)	177 (70.5)	392 (78.1)	1159 (70.5)
Diabetes	1208 (28.1)	210 (29.9)	328 (27.2)	63 (25.1)	155 (30.9)	452 (27.5)
Renal impairment	617 (14.3)	109 (15.5)	151 (12.5)	37 (14.7)	75 (14.9)	245 (14.9)
Liver cirrhosis	60 (1.4)	12 (1.7)	13 (1.1)	3 (1.2)	8 (1.6)	24 (1.5)
Cancer	402 (9.3)	65 (9.2)	109 (9.1)	27 (10.8)	40 (8.0)	161 (9.8)
Dementia	1315 (30.6)	270 (38.4)	195 (16.2)	150 (59.8)	294 (58.6)	406 (24.7)
Falls in the last month	1100 (25.6)	224 (31.9)	247 (20.5)	81 (32.3)	195 (38.8)	353 (21.5)
Medication use						
Anticoagulant use	1116 (25.9)	183 (26.0)	364 (30.2)	62 (24.7)	139 (27.7)	368 (22.4)
Antiplatelet use	1566 (36.4)	278 (39.5)	443 (36.8)	90 (35.9)	190 (37.8)	565 (34.4)
Clinical features						
Loss of consciousness	325 (7.6)	240 (34.1)	0 (0.0)	0 (0.0)	30 (6.0)	55 (3.3)
Amnesia of event	611 (14.2)	361 (51.4)	0 (0.0)	0 (0.0)	143 (28.5)	107 (6.5)
Disorientation	769 (17.9)	450 (64.1)	0 (0.0)	0 (0.0)	166 (33.2)	153 (9.3)
Bruise or laceration	1659 (38.6)	526 (74.9)	863 (71.9)	199 (79.3)	31 (6.2)	40 (2.4)
GSC score (Median [IQR])	15 (0.0)	15 (1.0)	15 (0.0)	15 (1.0)	14 (1.0)	15 (0.0)
Suspected open or depressed skull fracture	11 (0.3)	3 (0.4)	1 (0.1)	5 (2.0)	1 (0.2)	1 (0.1)
Any signs of basal skull fracture	70 (1.6)	25 (3.6)	31 (2.6)	12 (4.8)	2 (0.4)	0 (0.0)
Vomited more than once	71 (1.7)	25 (3.6)	13 (1.1)	6 (2.4)	12 (2.4)	15 (0.9)
Clinical frailty score (Median [IQR])	4 (3.0)	5 (3.0)	4 (2.0)	6 (2.0)	6 (2.0)	4 (3.0)
Intracranial bleeding						
Clinically important intracranial bleeding	139 (3.2)	54 (7.7)	30 (2.5)	19 (7.6)	23 (4.6)	13 (0.8)

(Continues)

TABLE 1 | (Continued)

Category	Number (%) of patients					
	Total	(a) Hit head and met CCTHR criteria	(b) Hit head but did not meet CCTHR criteria	(c) Hit head but unclear history of CCTHR criteria	(d) Unclear head injury status	(e) Did not hit their head
	***N*=4303**	***N*=703**	***N*=1204**	***N*=251**	***N*=502**	***N*=1643**
Any intracranial bleeding (important and not important)	173 (4.0)	73 (10.4)	40 (3.3)	23 (9.2)	23 (4.6)	14 (0.8)
Death						
Death within 42 days of index visit	185 (4.3)	30 (4.3)	31 (2.6)	24 (9.6)	36 (7.2)	64 (3.9)

3.2 | Prevalence of Clinically Important Intracranial Bleeding

Clinically important intracranial bleeding was diagnosed in 139 patients (3.2%). The prevalence of intracranial bleeding in each subgroup was as follows (Table 2): (a) hit their head and met CCTHR application criteria: 54/703 (7.7%, 95% CI: 5.9%–9.9%); (b) hit their head but did not meet CCTHR application criteria: 30/1204 (2.5%, 95% CI: 1.7%–3.5%); (c) hit their head with an unclear history of the CCTHR criteria: 19/251 (7.6%, 95% CI: 4.9%–11.5%); (d) had no clear history/examination findings of hitting their head: 23/502 (4.6%, 95% CI: 3.1%–6.8%); (e) did not hit their head: 13/1643 (0.8%, 95% CI: 0.5%–1.3%).

After adjusting for the use of CT head scanning on the index visit, compared to no head injury, the odds ratios for clinically important intracranial bleeding were: group (a) 4.3 (95% CI: 2.2%–8.3%), group (b) 1.5 (95% CI: 0.8%–3.0%), group (c) 4.5 (95% CI: 2.1%–9.6%), group (d) 2.8 (95% CI: 1.4%–5.8%).

4 | Discussion

In this study, patients who hit their head with an unclear history of CCTHR application criteria had a similar, high prevalence of intracranial bleeding compared to those who hit their head and met the CCTHR application criteria (7.6% and 7.7% respectively). In cases where it was unclear whether the patient had a head injury, there was an elevated risk of intracranial bleeding (4.6%). Patients who did not hit their head during the fall had minimal risk of intracranial bleeding (0.8%).

Cognitive impairment may compromise a patient's ability to give a history. Moderate and severe renal impairment has an association with cognitive impairment [15] and is also associated with intracranial bleeding [16, 17]. Cerebral amyloid angiopathy and arteriolosclerosis are associated with dementia and intracranial bleeding [18–20]. In some cases, it is possible that the patient falls as a result of a spontaneous intracranial bleed.

The presence of cognitive impairment can worsen many risk factors associated with falling including mobility deficits, lack of insight of activity consequences, and difficulty in performing tasks requiring undivided attention [21]. Additionally, patients who are unable to recount the events of a fall may have experienced a head injury with loss of consciousness or amnesia (i.e., a more severe head injury).

One other study found a lower rate of intracranial bleeding in patients with an unclear history of head injury (1.6%, 95% CI: 1.0%–2.6%) [22]. The difference could be explained by the inclusion of all types of trauma (not only ground-level falls) and classification based on chart review. Our exposure data were recorded by the treating physician, the true physician's impression following history and examination.

It is important to acknowledge several limitations of the study. This study is a secondary analysis of an existing dataset. Although the original study shared the same primary outcome, the exposures of interest differed. Participating physicians documented whether head injury, loss of consciousness, disorientation, or amnesia were present. We did not assess the interobserver variability in these observations. Patients were recruited at 10 Canadian and one American emergency department, meaning these results may be less generalizable to other populations. Our study did not collect data on ethnicity or race [23]. Intracranial bleeding may have been missed because not all patients had a head CT scan at the index visit and patients could attend a different hospital system during follow-up.

From a clinical standpoint, our results support emergency physicians ordering brain imaging for falls patients who hit their head and also when head impact cannot be excluded. Overall, 38% of the cohort had no history of head impact on their fall, and among those patients, the prevalence of intracranial bleeding was only 0.8% (95% CI: 0.5%–1.3%). Shared decision making with the patient/family about risks (in some cases a longer stay, the need for sedation or hospital transfer) and benefits (diagnosis of intracranial bleeding in 1 in 100 patients, where some cases may require intervention), could be an appropriate option. Notably, the newly derived Falls Decision Rule [8, 24] would also require no new neurodeficit, no amnesia of the fall and that the Clinical Frailty Scale score is < 5 to determine that brain imaging is not needed for these patients.

TABLE 2 | Risk of Intracranial Bleeds.

Category	Intracranial bleeds/ all patients	Intracranial bleed prevalence % (95% CI)	Adjusted* OR for intracranial bleed (95% CI)
(a) Hit head and met CCTHR	54/703	7.7 (5.9–9.9)	4.3 (2.2–8.3)
(b) Hit head but did not meet CCTHR criteria	30/1204	2.5 (1.7–3.5)	1.5 (0.8–3.0)
(c) Hit head but history of CCTHR criteria unclear	19/251	7.6 (4.9–11.5)	4.5 (2.1–9.6)
(d) Unclear head injury status	23/502	4.6 (3.1–6.8)	2.8 (1.4–5.8)
(e) Did not hit their head	13/1643	0.8 (0.5–1.3)	Reference

Abbreviation: CCTHR criteria = patient experienced loss of consciousness, amnesia of the event or disorientation post head injury.
*Adjusted for use of head CT at index visit.

Given the tension between missing the diagnosis of intracranial bleeding and the move toward avoiding unnecessary brain imaging [25], validation of protocols involving withholding brain imaging in older adults who fall is vital to ensure future emergency medicine testing protocols are safe and take patient values into account. Further research focused on older falls patients with no head injury will be critical to guide safe practice in this subgroup. Future external validation of clinical decision-making tools for older adults who fall, such as the Falls Decision Rule [8] and the Florida Geriatric Head Trauma CT [26] rule should include patients who hit their head and those where head injury is unclear, ensuring the rules are applicable to older adults who are unable to remember or communicate what happened.

In conclusion, our study found that older adults who hit their head during a fall but have an unclear history of the CCTHR application criteria have an elevated risk of intracranial bleeding and should receive brain imaging. Patients with an unclear history of head impact also have an elevated risk of intracranial bleeding and should receive brain imaging. Conversely, those who clearly did not hit their head have minimal risk of clinically important intracranial bleeding over the next 42 days and may not require brain imaging.

Author Contributions

The study was conceived by Kerstin de Wit and Geoff Kerr. The analysis was done by Geoff Kerr and Allie Chown. All co-authors were involved in data collection for the primary study. The manuscript was drafted and approved by all co-authors.

Disclosure

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

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