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Selected Topics: Emergency Radiology

Computed Tomography Imaging of Geriatric Patients with Uncertain Head Trauma

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□ **Abstract—Background: Although clinical decision rules exist for patients with head injuries, no tool assesses patients with unknown trauma events. Patients with uncertain trauma may have unnecessary brain imaging. Objective: This study evaluated risk factors and outcomes of geriatric patients with uncertain head injury. Methods: This prospective cohort study included geriatric patients with definite or uncertain head injury presenting to two emergency departments (EDs). Patients were grouped as definite or uncertain head trauma based on history and physical examination. Outcomes were intracranial hemorrhage (ICH) on head computed tomography (CT), need for neurosurgical intervention, and mortality. Risk factors assessed included gender, alcohol use, tobacco use, history of dementia, anticoagulant use, antiplatelet use, and Glasgow Coma Scale (GCS) score < 15. Results: We enrolled 2905 patients with definite head trauma and 950 with uncertain head trauma. Rates of acute ICH (10.7% vs. 1.5%; odds ratio [OR] 8.02; 95% confidence interval [CI] 4.67–13.76), delayed ICH (0.7% vs. 0.1%; OR 6.58; 95% CI 4.67–13.76), and neurosurgical intervention (1.2% vs. 0.3%; OR 3.74; 95% CI 1.15–12.20) were all higher in definite vs. uncertain head injuries. There were no differences in mortality. Patients with definite trauma had higher rates of ICH with male gender (OR 1.58; 95% CI 1.24–1.99), alcohol use (OR 1.62; 95% CI 1.25–2.09), antiplatelet use (OR 1.84; 95% CI 1.46–2.31), and GCS score < 15 (OR 3.24; 95% CI 2.54–4.13). Patients with uncertain trauma had no characteristics associated with increased ICH. Conclusions: Although ICH rates among patients with uncertain head trauma was eight times lower than those with definite head trauma, the risk of ICH is high enough to warrant CT imaging of all geriatric patients with uncertain head injury.**

□ **Keywords—Head trauma; Geriatrics; Head imaging; Emergency medicine**

Introduction

In U.S. adults older than 65 years, falls are the most common cause of injury-related morbidity and mortality. In 2014, there were 2.8 million people treated for falls, of which 800,000 were hospitalized and 27,000 died (1). There are multiple reasons for this. For example, the geriatric population are less likely to protect their heads with their arms during a fall and cerebral atrophy increases tension on the bridging veins, which are also relatively fragile with to the younger population (2–4). When patients fall and sustain a minor head injury, there is a 7.2% rate of intracranial injury (5). However, many patients do not recall whether they actually hit their head due to issues such as poor memory, cognitive decline, and possible loss of consciousness (LOC).

The Canadian CT Head Rule (CCHR) was first published in 2001 as a way to clear patients with head injuries without the need for brain imaging, with inclusion criteria of LOC, definite amnesia, or witnessed disorientation; initial emergency department (ED) Glasgow Coma Scale (GCS) score ≥ 13, as determined by the treating physician; and injury within the past 24 h (6). Although the

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CCHR has been externally validated with 100% sensitivity, approximately 50% of patients with minor head trauma who received a computed tomography (CT) scan of the head did not meet CCHR criteria (7,8). Since the publication of CCHR, there has been a 3-fold increase in the number of CTs and magnetic resonance imaging during ED visits for injury-related conditions between 1998 and 2007, without a significant increase in detection of emergent conditions (9).

A 2019 study reported a 7.3% head CT positivity rate for patients older than 65 years with a fall. The factors most predictive of positive head CT were findings of head trauma on physical examination, history of head trauma, and history of LOC. Of these three factors, having a history of hitting head was almost double the other two factors. This study also found that using these high-risk predictors yielded a sensitivity of 86.5% and a negative predictive value of 97.3%. The study concluded that if only LOC and signs of head trauma were applied as a clinical decision rule, 48.1% patients would not have had a head CT and only 2.7% would have been missed, all of which did not require surgical intervention (10).

Although the CCHR has been helpful in the population it was designed for, the CCHR is unable to rule out the need for head CT in patients who are older than 65 years and amnestic to the event (6). There are currently no sufficient rules to use for patients who are unaware of a potential head trauma event, especially in those older than 65 years. Patients who potentially sustained a head trauma but are uncertain due to LOC, dementia, or simply not recalling, pose a dilemma for treating physicians. Standard practice of emergency physicians is generally to perform a CT head in patients with possible head injury, even when there is no evidence of trauma and the patient cannot recall actually hitting their head. This leads to excessive and possibly unnecessary head CTs, which may be costly from time, resource utilization, and monetary perspectives. However, there is no prior evidence that patients with uncertain head injury require head CT imaging.

This study examined the dilemma of geriatric patients who present to the ED with uncertainty about whether head trauma has occurred. Specifically, we evaluated the rate of acute intracranial hemorrhage (ICH) in patients with uncertain head trauma and evaluate risk factors for ICH.

Materials and Methods

Study Design and Participants

This is a prospective cohort study of patients presenting to the EDs of two level I, university-affiliated trauma centers with annual volumes of 50,000 and 69,000. Both facilities are located in the same South Florida county and are the only two trauma centers serving that county. The emergency medical services (EMS) protocols used throughout the county require that any EMS patient who meets the Centers for Disease Control and Prevention Guidelines for Field Triage of Injured Patients be taken to one of these facilities (11). The study received approval from the hospitals' and affiliated university's Institutional Review Boards.

Study enrollment occurred from August 2019 to August 2020. Daily, trained research assistants screened all patients older than 65 years who had an ED head CT or had an International Classification of Diseases, Tenth Revision (ICD-10) diagnosis code beginning with S00 to S09, including all head injury–related codes (12). The research assistants performed chart reviews of emergency physician notes to include patients who had definite head trauma or suspicion for head trauma. Any patients that the research assistants were unclear about or who clearly did not meet study inclusion criteria were reviewed by one of the study investigators to ensure screening accuracy. Exclusion criteria consisted of patients in whom the injury or potential injury occurred $>$ 24 h prior to presentation, patients with penetrating injuries, patients transferred from another acute care hospital, and patients with a GCS score $<$ 13 without a history of dementia.

Measurements

Patients included in the study had a chart review performed by trained research assistants. Variables extracted from the chart included age, gender, tobacco use, alcohol use, ED disposition, anticoagulant use, antiplatelet use, head CT results, repeated head CT results, ED ICD-10 diagnosis codes, history of dementia, mechanism of injury, LOC, reported headache, and signs of head trauma on physician examination. After 90 days from each patient's hospital presentation, the Florida Bureau of Vital Statistics death registry was queried to determine whether the patient had died. All data were entered into the REDCap database system with real-time data parameter validation.

Determination of definite head trauma was defined as report of certain head injury in the history of present illness, physical examination findings of head injury (including hematoma, laceration, abrasion, raccoon eyes, hemotympanum, and battle sign), report of headache with concern of possible trauma, or having a CT positive for extracranial findings. If a patient did not meet any of these definite head trauma criteria, they were categorized as having uncertain head trauma. This included patients who did not explicitly report a head injury, did not report a headache after possible trauma, and had no physical examination findings suggestive of head trauma.

Outcomes

The primary study outcome was traumatic ICH diagnosed on head CT scan. Head CT imaging results, as interpreted by non–study attending radiologists, were coded as positive for acute ICH or negative for acute ICH. This included any type of ICH, that is, epidural, subdural, subarachnoid, intraparenchymal, or intraventricular hemorrhages. Physician study investigators further evaluated each positive head CT as a delayed or acute ICH based on initial CT and any other previous or subsequent head imaging. Secondary outcomes included need for neurosurgical intervention, in-hospital mortality, and 90-day mortality.

Analysis

Patients were grouped by definite vs. uncertain head trauma. Rates of acute and delayed ICH, need for neurosurgical intervention, in-hospitality mortality, and 90-day mortality were compared between groups using χ^2 tests and odds ratios (ORs). Patients were then grouped by presence or absence of ICH and characteristics were compared between definite vs. uncertain for each of these groups. These characteristics included anticoagulant use, antiplatelet use, combined anticoagulant and antiplatelet use, GCS score from 13 to 14, history of dementia, alcohol abuse, tobacco use, gender, and age > 80 years. Statistical analyses were performed using SPSS, version 27.0 (IBM Corp.).

Results

Characteristics of Study Subjects

There were 3855 patients who met study inclusion criteria; 2905 of these patients (75.3%) had definite head trauma and 950 (24.7%) had uncertain head trauma. Mean (SD) age of those with definite head trauma was 82.0 (8.8) years vs. 82.3 (8.8) years for those with uncertain head trauma. Background characteristics were similar between the two groups, although rates of anticoagulant use, antiplatelet use, tobacco use, and alcohol use tended to be higher in the uncertain head trauma group (Table 1).

Main Results

The rate of any ICH was 11.4% for those with definite head trauma and 1.7% for those with uncertain head trauma (OR 7.53; 95% CI 4.54–12.51; $p < 0.001$). The rate of acute ICH was 10.7% for those with definite head trauma and 1.5% for those with uncertain head trauma (OR 8.02; 95% CI 4.67–13.76; $p < 0.001$). The rate of delayed ICH was 0.7% for those with definite head trauma and 0.1% for those with uncertain head trauma (OR 6.58; 95% CI 0.88–49.09; $p = 0.034$) (Table 2).

Of patients with acute ICH, 1.2% with definite head trauma required neurosurgical intervention and 0.3% with uncertain head trauma required neurosurgical intervention (OR 3.74; 95% CI 1.15–12.20; $p = 0.019$). No patients with delayed ICH required neurosurgical intervention. Patients with definite head trauma tended to have lower in-hospital and 90-day mortality than patients with uncertain head trauma, although this was not significant (Table 2).

Of patients with definite head trauma, the characteristics associated with a higher rate of ICH were antiplatelet use, combined anticoagulant and antiplatelet use, GCS score < 15, alcohol use, and male gender. Anticoagulant use, dementia, tobacco use, and age > 80 years were not associated with a higher rate of ICH (Table 3). Patients with uncertain head trauma had no identified characteristics associated with an increased rate of ICH (Table 4).

Discussion

In this prospective cohort study of patients presenting to the EDs of two level I, university-affiliated trauma centers, we found that patients aged > 65 years with definite head trauma were eight times more likely to have sustained an ICH than patients with uncertain head trauma. Of patients with uncertain head trauma, 1.7% had an ICH found on head CT. Within this subset, there were no specific characteristics identifiable that predicted higher rates of ICH.

In the setting of a potentially fatal diagnosis, had no CT imaging been performed on patients with uncertain head trauma, there would have been a 1.7% ICH miss rate with 0.3% of those requiring neurosurgical intervention. This rate was similar to another study that showed only 0.4–1% of all ICHs needs neurosurgical intervention (4). Taking this into consideration, we believe that although prior studies have reported an increase in head imaging and no significant increase in emergent finding detection, our study found that perhaps the imaging of patients with low suspicion for ICH is still prudent, as 1.7% is too high of a number to miss (1). Over their career, one physician could miss tens or hundreds of ICHs that have a potential for earlier recognition and possible intervention. We therefore recommend that geriatric patients with uncertain head trauma receive a head CT.

In addition to the 1.7% ICH rate for patients with uncertain head trauma, patients in our cohort who had definite head trauma had an 11% ICH rate. Therefore, and again taking into consideration the morbidity and mortality of this diagnosis in this population, we recommend all patients aged > 65 years with definite head trauma receive a CT scan.

Table 1. Background Characteristics of Patients with Definite Trauma, Uncertain Trauma, and Combined

Characteristic	Definite Trauma, n (%) (n = 2905)	Uncertain Trauma, n (%) (n = 950)	Combined, n (%) (n = 3855)
Anticoagulant use	798 (27.5)	291 (30.6)	1089 (28.2)
Antiplatelet use	1086 (37.4)	370 (38.9)	1456 (37.8)
Both anticoagulant and antiplatelet use	184 (6.3)	93 (9.8)	277 (7.2)
Glasgow Coma Scale score < 15	575 (19.8)	166 (17.5)	741 (19)
Dementia	517 (19.7)	185 (19.5)	756 (19.6)
Alcohol abuse	608 (20.9)	213 (22.4)	821 (21.3)
Tobacco use	112 (3.9)	65 (6.8)	177 (4.6)
Male gender	1332 (45.9)	443 (46.6)	1775 (46)
Age > 80 years	1583 (61.5)	582 (62.3)	2165 (56.1)

Table 2. Outcomes of Patients with Definite vs. Uncertain Head Trauma

Outcome	Definite Trauma, n (%) (n = 2905)	Uncertain Trauma, n (%) (n = 950)	OR (95% CI)	*p* Value
ICH overall	331 (11.4)	15 (1.6)	8.02 (4.75–13.52)	< 0.001
Acute ICH	311 (10.7)	14 (1.5)	8.02 (4.67–13.76)	< 0.001
Delayed ICH	20 (0.7)	1 (0.1)	6.58 (0.88–49.09)	0.034
Neurosurgical intervention	34 (1.2)	3 (0.3)	3.74 (1.15–12.20)	0.019
In-hospital mortality	20 (0.7)	12 (1.3)	0.54 (0.26–1.11)	0.090
Death in < 90 d	345 (11.9)	130 (13.7)	0.85 (0.69–1.06)	0.141

ICH = intracranial hemorrhage; OR = odds ratio; CI = confidence interval.

Table 3. Rate of Intracranial Hemorrhage for Patients With Definite Head Trauma by Presence of Characteristics

Characteristic	Present, n (%)	Absent, n (%)	OR (95% CI)	*p* Value
Anticoagulant	88 (11.0)	243 (11.5)	0.95 (0.73–1.23)	0.70
Antiplatelet	167 (15.4)	164 (9.0)	1.84 (1.46–2.31)	< 0.001
Both anticoagulant and antiplatelet	41 (22.3)	290 (10.7)	2.40 (1.66–3.47)	< 0.001
GCS score < 15	133 (23.1)	198 (8.5)	3.24 (2.54–4.13)	< 0.001
Dementia	61 (10.7)	270 (11.6)	0.91 (0.68–1.23)	0.55
Alcohol abuse	95 (15.6)	236 (10.3)	1.62 (1.25–2.09)	< 0.001
Tobacco use	9 (8.0)	322 (11.5)	0.67 (0.34–1.34)	0.25
Male gender	185 (13.9)	146 (9.3)	1.58 (1.24–1.99)	< 0.001
Age > 80 y	208 (11.6)	123 (11.1)	1.06 (0.83–1.34)	0.65

GCS = Glasgow Coma Scale; OR = odds ratio; CI = confidence interval.

Table 4. Rate of Intracranial Hemorrhage for Patients with Uncertain Head Trauma by Presence of Characteristics

Characteristic	Present, n (%)	Absent, n (%)	OR (95% CI)	*p* Value
Anticoagulant	4 (1.4)	11 (1.7)	0.82 (0.26–2.60)	0.74
Antiplatelet	7 (1.9)	8 (1.4)	1.38 (0.50–3.84)	0.54
Both anticoagulant and antiplatelet	2 (2.2)	13 (1.5)	1.43 (0.32–6.42)	0.64
GCS score < 15	2 (1.2)	13 (1.7)	0.72 (0.16–3.24)	0.67
Dementia	1 (0.5)	14 (1.8)	0.29 (0.04–2.23)	0.21
Alcohol abuse	6 (2.8)	9 (1.2)	2.35 (0.83–6.66)	0.10
Tobacco use	0 (0.0)	15 (1.7)	—	0.29
Male gender	10 (2.3)	5 (1.0)	2.32 (0.79–6.84)	0.12
Age > 80 y	7 (1.2)	8 (2.2)	0.53 (0.19–1.48)	0.22

GCS = Glasgow Coma Scale; OR = odds ratio; CI = confidence interval.

Although there were no risk factors associated with ICH among those with uncertain head trauma, patients with antiplatelet use, both anticoagulant and antiplatelet use, GCS score < 15, alcohol use, and male gender were found to have increased risk of ICH in patients with definite head trauma. We suggest that physicians have increased suspicion for ICH in patients with these characteristics, even with uncertain head trauma. Surprisingly, dementia was not a factor found to be associated with ICH for either definite or uncertain head trauma. Therefore, dementia does not need to be factored into the decision to perform head CT imaging in these patients.

Another interesting finding was the greater, although not statistically significant, rate of in-hospital and 90-day mortality in patients with uncertain head trauma. Perhaps patients with uncertain head trauma had other etiologies for their ED visit, such as nonhead injuries, syncopal or near-syncopal episodes, possible amnesia associated with the event, or alcohol or drugs associated with the event. These alternative possibilities may have been the reason for increased mortality, rather than an uncertain head injury. Patients who are healthier may be more likely to remember what occurred during or before a fall, and patients less healthy may not.

Although a goal of this study was to attempt to reduce the number of CTs performed on patients who present with uncertain head trauma, we were unable to identify any specific lower-risk characteristics of these patients. Future research could attempt to create a clinical decision rule for geriatric patients who sustain head trauma.

Limitations

The main limitation of this study relates to the criteria used for definite head trauma. Because of the nature of some ED visits, it can be difficult to determine the exact indication for the visit. Although most of the criteria used to define definite head trauma are clear and objective, some of the criteria are subjective. This may lead to some of the patients in the study being sorted incorrectly. For instance, radiology reports may not always note extracranial findings, and ED notes may have been missing documentation of definite head injury, causing patients with definite head trauma to be placed into the uncertain head trauma category. Patients who had uncertain head trauma but did not receive head CT imaging or an ICD-10 diagnosis in the initial patient screening may have also been missed for inclusion. There may have been a spectrum bias as well, given that the study hospitals are both level I trauma centers and may have a higher-acuity population than other sites. In addition, physicians did not have a clinical decision rule to use when determining the need for head CT on patients with uncertain trauma. This introduces a variety of practice patterns and subjectivity.

Another limitiation is the possibility for missed delayed bleeds, as patients could have re-presented to a non–study hospital. Although if a delayed bleed was found, the patient should have been transferred back to one of the study hospitals per county-wide trauma center transfer criteria. Similarly, there may have been missed deaths if a patient died in another state within 90 days after the injury.

Conclusions

Patients who had definite head trauma were eight times more likely to sustain an ICH than patients with uncertain head trauma. Risk factors associated with higher rates of ICH among patients with definite head trauma included antiplatelet use, both anticoagulant and antiplatelet use, GCS score < 15, alcohol use, and male gender. However, patients with uncertain head trauma had a 1.7% rate of ICH, and there were no identifiable characteristics associated with a higher ICH rate in this group. Although 1.7% is not a large number, we believe it is still prudent to perform CT imaging on all patients aged > 65 years who have definite or uncertain head trauma.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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