Head Computed Tomography Scans in Elderly Patients with Low Velocity Head trauma after a Fall

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ABSTRACT **Background:** Recommendations for a head computed tomography (CT) scan in elderly patients without a loss of consciousness after a traumatic brain injury and without neurological findings on admission and who are not taking oral anticoagulant therapy, are discordant.

Objectives: To determine variables associated with intracranial hemorrhage (ICH) and the need for neurosurgery in elderly patients after low velocity head trauma

Methods: In a regional hospital, we retrospectively selected 206 consecutive patients aged ≥ 65 years with head CT scans ordered in the emergency department because of low velocity head trauma. Outcome variables were an ICH and neurological surgery. Independent variables included age, sex, disability, neurological findings, facial fractures, mental status, headache, head sutures, loss of consciousness, and anticoagulation therapy.

Results: Fourteen patients presented with ICH (6.8%, 3.8–11.1%) and three (1.5%, 0.3–4.2%) with a neurosurgical procedure. One patient with a coma (0.5, 0.0–2.7) died 2 hours after presentation. All patients who required surgery or died had neurological findings. Reducing head CT scans by 97.1% (93.8–98.9%) would not have missed any patient with possible surgical utility. Twelve of the 14 patients (85.7%) with an ICH had neurological findings, post-trauma loss of consciousness or a facial fracture were not present in 83.5% (95% confidence interval 77.7–88.3) of the cohort.

Conclusions: None of our patients with neurological findings required neurosurgery. Careful palpation of the facial bones to identify facial fractures might aid in the decision whether to perform a head CT scan.

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KEY WORDS: **KEY WORDS:** computed tomography (CT) brain imaging, elderly, facial fracture, intracranial hemorrhage, traumatic brain injury (TBI)

Falls are common in the elderly, but the appropriate criteria for a head computed tomography (CT) is still largely undefined [1]. The risk for radiation-induced malignancy is a consideration in younger patients [2] but is less important in elderly patients with a shorter expected life span. However, obtaining a CT scan and waiting interpretation adds to the length of stay in the emergency department (ED), contributing to overcrowding and increasing costs [3]. ED crowding has negative consequences including poorer patient outcomes and the inability of staff to adhere to guideline-recommended treatment [4].

Experts recommend either universal CT head scanning in elderly patients or limiting testing to patients with loss of consciousness or decreased consciousness on admission after a traumatic brain injury, or treatment with an oral anticoagulant [5-13]. Commonly, emergency departments continue to use the 2008 recommendations of the American College of Emergency Physicians [10-13] to scan anyone 65 years of age or older after a head trauma, without distinction. However, there are studies that have adopted commonly used criteria for a CT head scan but have excluded age as single criteria for testing [8]. Furthermore, 50% of the 71 trauma centers in Europe do not order a CT scan in patients aged 60 years or older without other risk factors [9].

We studied the risk of an intracranial bleed in elderly patients with head trauma after a fall, and attempted to predict those with an intracranial hemorrhage (ICH) with and without surgical intervention.

PATIENTS AND METHODS

We included all hospitalizations in 2017 in an internal medicine emergency department patients aged 65 years or more, and reviewed all cases where a head CT scan was conducted. There were 9364 patients and 412 head CT scans performed (4.4%) [Table 1]. All elderly patients after head trauma are hospitalized for at least 24 hours.

We selected those with low velocity head trauma after a fall (N=206). Falls were a defined as a sudden involuntary change

Table 1. Reasons for head CT scan in 412 patients

Reasons for CT scan	Number (%)
Head trauma	206 (50.0)
Acute stroke	48 (11.7)
Transient ischemic attack	16 (3.9)
Deterioration/weakness	44 (10.7)
Decreased mental status	29 (4.0)
Headaches	13 (3.2)
Seizures	14 (3.4)
Vertigo	13 (3.2)
Loss of consciousness	12 (2.9)
Coma	5 (1.2)
Before lumbar puncture	4 (1.0)
Other conditions*	8 (1.9)

*dysarthria-1, hemianopsia-1, arrhymia-2, shoulder injury-1, suspected cerebral vascular accident-3
CT = computed tomography

from a vertical position, from a standing position. Patients slipping off a bed or a chair receiving a head CT scan were also included. Predictor variables included age (≥ 80 years), sex, and loss of consciousness after falling, facial fractures (nose or sinus), a pre-trauma modified Rankin score ≥ 3 (requires some help, but able to walk unassisted), facial/scalp sutures, and neurological signs on admission. Minimal brain trauma was defined as no loss of consciousness after the fall, retrograde amnesia, oral anticoagulation treatment, or neurological findings on admission, including an acute decrease in mental status. The outcome variables were an ICH and the need for neurosurgery.

STATISTICAL ANALYSIS

We calculated proportions and relative risks with 95% confidence intervals. Furthermore, we determined the sensitivity of various criteria to identify an ICH and the proportion of CT scans that would not be ordered in the absence of the individual criteria. Logistic regression analysis was not done because of small numbers.

The study was approved by the local ethics committee (0032-18 LND), which is reviewed by the Ministry of Health. Patient informed consent was waived.

RESULTS

There were 412 CT head scans performed in the emergency department for patients aged 65 years or older [Table 1]. Of those patients, head trauma was the cause for referral in 50.0% (N=206). There were 14 ICHs (6.8%, 3.8–11.1%) and three (1.5%, 0.3–4.2%) with a neurosurgical procedure. One patient presenting with a coma (0.5, 0.0–2.7) died 2 hours after arriving [Table 2]. Intracranial bleeds were more common in males, in patients with a headache, in those presenting with neurological signs or loss of consciousness after the fall, and in those with facial fractures [Table 3] but the confidence limits of the relative risks were wide because of small numbers. Age ≥ 80 years, need for head sutures, oral anticoagulation, and Rankin grade 3 were not associated with an intracranial bleed.

All of the patients who died or required neurosurgery had neurological signs on admission (N=4) [Table 4], which were not found in 97.1% (200/206) (93.8–98.9%) of the patients. Seven of the 14 patients with an ICH had only a minimal brain injury, but adding a facial fracture identified 12 of the 14 patients (85.7%), not found in 83.5% (95% confidence interval [95%CI] 77.7–88.3) of the cohort. Adding Rankin scale 3 or greater identified all patients with an ICH, and was not found in 108 of the 206 patients (52.4%, 95%CI 45.4–59.4).

DISCUSSION

The major finding of this study was that no elderly patient presenting with head trauma without neurological findings on admission had a serious ICH that lead to death or the need for a neurosurgical procedure. If patients without neurological signs did not have a head CT ordered, there would be a 97.1% reduction in tests performed in patients referred for head trauma.

However, it is unclear if prediction models should attempt to detect all patients with ICH or only those with clinically important lesions and whether early diagnosis of a traumatic ICH will improve the clinical outcome. We found that CT scans in patients presenting with neurological signs, post-trauma loss of consciousness, treatment with oral anticoagulants, or facial fractures detected 85.7% of those with an ICH and if used as the criteria for ordering a CT head scan would reduce testing by 83.5%. This finding is consistent with a study that found that CT-detected skull fractures were the strongest clinical predictors for an ICH in the elderly [6]. However, in our study, although the CT scan identified the facial fracture, all of whom complained of a headache, it is unclear if sensitivity to palpation could detect all those with a nose or sinus fracture, and with what proportion of false positives. There is one study reporting that the physical examination had approximately 90% sensitivity and specificity in identifying a nasal fracture [14]. We did not find that the need for head sutures was more common in those with an ICH; thus, facial fractures might be a more specific indicator than any evidence of trauma above the clavicle.

One study of elderly patients without mental status changes reported that those without signs of head trauma including contusions, abrasions, lacerations, avulsions, or ecchymosis had

Table 2. Fourteen patients with intracranial bleeding after low velocity head trauma

Age/sex	Rankin scale*	Facial Fracture	LOC	Neurological signs	Diagnosis and other relevant clinical considerations	Intervention
92/Female	3	–	+	Coma	Acute and chronic SDH- midline deviation	Died 2 hours after admission
86/Male	3	–	–	Confusion, and unsteady gait	Chronic and re-bleed SDH +mass effect	Craniotomy
65/Male	0–2	–	–	Dysarthria	SDH+ parenchymal edema, brain herniation	Craniotomy
84/Male	0–2	Maxillary sinuses	+	Post-trauma amnesia	Parenchymal bleed	Shunt
66/Male	0–2	–	+	None	SDH	No treatment
66/Male	0–2	–	+	None	SDH	No treatment
79/Female	3	Nose	–	None	SDH, anticoagulants for atrial fibrillation.	Stop anticoagulants, neurosurgery consult
Minimal brain trauma without chronic anticoagulation treatment						
67/Female	3	Nose	–	LOC before fall	SDH	Neurosurgery consult
68/Male	0–2	Nose	–	None	SAH	No treatment
76/Male	0–2	Nose and maxillary sinus	–	None	SDH and parenchymal bleed	No treatment
81/Male	0–2	Maxillary sinus	–	None	SDH	No treatment
87/Male	0–2	Nose	–	None	SDH	No treatment
83/Male	3	–	–	Parkinson's disease	SAH both hemispheres	Neurology consult, no treatment
87/Male	3	–	–	None	SDH	No treatment

*Rankin scale; 0–2 = none to slight disability, 3 = requires some help, > 3 = unable to attend to own bodily needs without assistance, and unable to walk unassisted
AF = atrial fibrillation, LOC = loss of consciousness after fall, SDH = subdural hemorrhage, SAH = subarachnoid hemorrhage

Table 3. Low velocity head trauma in 206 elderly patients comparing those with and without intracranial bleeding

Predictor	No bleeding (N=192), n (%)	Bleeding (N=14), n (%)	Relative risk (95% confidence interval)
Males	75 (39.1)	11 (78.6)	2.0 (1.5–2.8)
Age, in years ≥ 80	116 (60.4)	7 (50.0)	0.8 (0.5–1.4)
Oral anticoagulants	7 (3.6)	1 (7.1)	2.0 (0.3–14.8)
Rankin ≥ 3	72 (29.0)	5 (35.7)	1.0 (0.7–1.5)
Head sutures	21 (10.9)	1 (7.1)	0.7 (0.1–4.5)
Headache	150 (78.1)	14 (100)	1.3 (1.2–1.4)
Facial fractures	16 (8.3)	7 (50.0)	6.0 (3.0–12.1)
Neurological signs*	2 (1.0)	4 (28.6)	27.4 (5.5–137.0)
Loss of consciousness**	2 (1.0)	4 (28.6)	27.4 (5.5–137.0)

*neurological signs: dysphagia, stupor, confusion with unsteady gait, coma, post-trauma amnesia, and confusion at admission (n=2)
**after the trauma

a rate of 2.6% of ICH compared to 7.3% of those with signs of head trauma [15]. However, the specificity was only 37.8%. None had neurosurgery. Another study identified all elderly patients with an ICH if they had a headache or evidence of trauma above the clavicle but the specificity was only 16.2% [16].

Our results are consistent with the results of six previous studies of elderly patients. Bennett and colleagues [16] studied 296 patients aged 65 years or older with a simple fall excluding those with multi-trauma. They found nine (3%) with ICH, but no patient required neurosurgery. In a second study, Davey and co-authors [17] reported that only 1.4% (2/137) of elderly patients > 65 years with minimal head injury had an ICH without need for neurosurgery. In a third study, 723 elderly patients selected for no change in mental status and not referred to the trauma bay, none had neurological procedures, and 52 (7.3%) had ICH [15]. In a fourth study, Riccardi et al. [18] excluded patients with any symptoms except in the area of trauma, on oral anticoagulant therapy, loss of consciousness after the event, a fall from over 1 meter height, neurological signs, previous neurosurgical intervention, neurological disorder, alcohol or illicit drugs assumption, and patients with abnormal conscious state

Table 4. Options for head CT scanning in the elderly with low velocity falls

Criteria	N, n (%, 95%CI)	Intracranial bleeds, n (%, 95%CI)	Surgery/death, n (%, 95%CI)
All patients	206	14 (6.8, 3.8–11.1)	4 (1.9, 0.5–4.9)
No neurological findings	200 (97.1, 93.8–98.9)	10 (5.0, 2.4–9.0)	0 (0.0, 0.0–1.8)**
Minimal injury*	195 (94.7, 90.6–97.3)	7 (3.6,1.5–7.3)	0 (0.0, 0.0–1.9)**
+No facial fracture	172 (83.5,77.7–88.3)	2 (1.2, 0.1–4.1)	0 (0.0, 0.0–2.1)**
+No Rankin-3	108 (52.4,45.4–59.4)	0 (0.0, 0.0–3.4)**	0 (0.0, 0.0–3.4)**

*no post-trauma loss of consciousness, neurological findings, or anticoagulation therapy
**97.5% one sided
95%CI = 95% confidence interval, CT = computed tomography

for dementia or psychosis. They reported a 1.6% rate of ICH (35/2149) requiring surgery in three patients (0.14%). ICHs were higher in those taking anti-platelet medications, and in those over age 80 years old but they did not report the clinical presentation of the three patients requiring surgery. Pages and colleagues [12] reported 7.6% ICHs in 500 elderly patients who fell (mean age 85 years) but only three (0.6%) required surgical intervention. Risk factors for an ICH included male sex, decreased consciousness, focal neurological findings and a past history of a post-traumatic brain injury. They did not report the details of those requiring emergency surgery, but none required surgery on follow-up. Finally, Gangavati et al [19] reported a 1.7% (7/404, 95%CI 0.7–3.5) rate of surgical interventions in elderly patients who fell and presented without focal neurological deficits, a 1.7% (7/404, 95%CI -0.7–3.5) rate, but details of post-trauma loss of consciousness or mental status on admission were not reported in those patients.

None of our patients deteriorated during hospitalization suggesting that the hospitalization was unnecessary. This finding is consistent with other reports. Campiglio et al. [20] reported that even in patients on anticoagulants a delayed traumatic ICH in patients with mild brain injury was 1.4% (4/284) and did not occur in any patient with Glasgow Coma Scale/Score (GCS) of 15 and an unremarkable neurological examination. An Israeli study of elderly patients with an ICH, a mild TBI and a high GCS score were non-operatively treated, discharged home in a relatively short time and did not experience any major drop in their functional status [21]. Marincowitz et al. [1] reported that patients with a small ICH, an initial GCS of 15, and a normal neurological examination did not die or require neurosurgery over a 30-day follow-up period. We had one patient with an ICH on oral anticoagulation therapy that was discontinued.

LIMITATIONS

Our study has a number of limitations. First, there were only 14 patients with an ICH; therefore, attempts to establish criteria to identify those patients are problematic and multivariate analysis is invalid. This finding, however, is inherent for any condition with an uncommon outcome measure and in itself demonstrates the low clinical utility of the procedure. Second, there is referral bias. Our hospital is regional, but all cases suspected as needing a neurosurgeon, are referred to larger hospitals in other areas. This method is unlikely to include patients with minimal brain trauma, but it is unclear how physicians determine which patient to refer. Finally, recommendations on the use of head CT scanning might be setting specific, and physicians might order a head CT in elderly patients without indications to reassure the patient, because of patient expectations, or the worry of legal liability [17].

CONCLUSIONS

Our patients without neurological findings did not require neurosurgery, and careful palpation of the facial bones to identify facial fractures might aid in the decision whether to perform a head CT scan. There is a need for multicenter studies to determine if this retrospective observation is an important predictor of an intracranial hemorrhage and more importantly indicative of the need for surgical intervention in elderly patients with a minimal brain injury.

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References

1. Marincowitz C, Lecky FE, Allgar V, et al. Development of a clinical decision rule for the early safe discharge of patients with mild traumatic brain injury and findings on computed tomography brain scan: a retrospective cohort study. *J Neurotrauma.* 2020; 37: 324-33.
2. Berrington de González A, Mahesh M, Kim KP, et al. Projected cancer risks from computed tomographic scans performed in the United States in 2007. *Arch Intern Med.* 2009; 169: 2071-7.
3. Gardner R, Sarkar U, Maselli J, Gonzales RJ. Factors associated with longer ED lengths of stay. *Am J Emerg Med* 2007; 25: 643-50.
4. Morley C, Unwin M, Peterson GM, Stankovich J, Kinsman L. Emergency department crowding: a systematic review of causes, consequences and solutions. *PLoS One.* 2018; 13: e0203316.

5. Ferorelli D, Donno F, De Giorgio G, et al. Head CT scan in emergency room: Is it still abused? Quantification and causes analysis of overprescription in an Italian Emergency Department. *Radiol Med* 2020; 125: 595-9.
6. Lampart A, Kuster T, Nickel CH, Bingisser R, Pedersen V. Prevalence and severity of traumatic intracranial hemorrhage in older adults with low-energy falls. *J Am Geriatr Soc* 2020; 68: 977-82.
7. Firsching R, Rickels E, Mauer UM, et al. Guidelines for the treatment of head injury in adults. *J Neurol Surg A Cent Eur Neurosurg* 2017; 78: 478-87.
8. DeAngelis J, Lou V, Li T, et al. Head CT for minor head injury presenting to the emergency department in the era of choosing wisely. *West J Emerg Med* 2017; 18: 821-9.
9. Foks KA, Cnossen MC, Dippel DWJ, et al. Management of mild traumatic brain injury at the emergency department and hospital admission in Europe: a survey of 71 neurotrauma centers participating in the CENTER-TBI study. *J Neurotrauma* 2017; 34 (17): 2529-35.
10. Dusenberry MW, Brown CK, Brewer KL. Artificial neural networks: predicting head CT findings in elderly patients presenting with minor head injury after a fall. *Am J Emerg Med* 2017; 35: 260-7.
11. Easter JS, Haukoos JS, Meehan WP, Novack V, Edlow JA. Will neuroimaging reveal a severe intracranial injury in this adult with minor head trauma?: The rational clinical examination systematic review. *JAMA* 2015; 314: 2672-81.
12. Pages PJ, Boncoeur-Martel MP, Dalmay F et al. A. Relevance of emergency head CT scan for fall in the elderly person. *J Neuroradiol* 2020; 47: 54-8.
13. Klang E, Beytelman A, Greenberg D, et al. Overuse of head CT examinations for the investigation of minor head trauma: analysis of contributing factors. *J AmColl Radiol* 2017; 14: 171-6.
14. Timashpolsky A, Dagum AB, Sayeed SM, Romeiser JL, Rosenfeld EA, Conkling N. A prospective analysis of physical examination findings in the diagnosis of facial fractures: determining predictive value. *Plast Surg (Oakv)* 2016; 24: 73-9.
15. Jeanmonod R, Asher S, Roper J et al. History and physical exam predictors of intracranial injury in the elderly fall patient: a prospective multicenter study. *Am J Emerg Med* 2019; 37: 1470-5.
16. Bennett JM, Nehus NR, Astin MR, Brown CK, Johnson R, Brewer KL. Use of cranial computed tomography (CT) in elderly patients presenting after a fall: can we predict those having abnormal head CT scans. *Br J Med Med Res* 2014; 6: 342-50.
17. Davey K, Saul T, Russel G, Wassermann J, Quaas J. Application of the Canadian computed tomography head rule to patients with minimal head injury. *Ann Emerg Med* 2018; 72: 342-50.
18. Riccardi A, Frumento F, Guiddo G, et al. Minor head injury in the elderly at very low risk: a retrospective study of 6 years in an emergency department (ED). *Am J Emerg Med* 2014; 31: 37-41.
19. Gangavati AS, Kiely DK, Kulchycki LK, et al. Prevalence and characteristics of traumatic intracranial hemorrhage in elderly fallers presenting to the emergency department without focal findings. *J Am Geriatr Soc* 2009; 57: 1470-4.
20. Campiglio L, Bianchi F, Cattalini C, et al. Mild brain injury and anticoagulants: less is enough. *Neurol Clin Pract* 2017; 7: 296-305.
21. Solomon D, Kaminski O, Schrier I, Kashtan H, Stein M. Isolated traumatic brain injury in the very old. *IMAJ* 2019; 12: 779-84.

What is the opposite of two? A lonely me, a lonely you.

Richard Wilbur (1921–2017), American poet and translator

It's surprising how much memory is built around things unnoticed at the time.

Barbara Kingsolver (born 1955), novelist, essayist, and poet

Heavy hearts, like heavy clouds in the sky,
are best relieved by the letting of a little water.

Christopher Morley (1890–1957), writer

Capsule

Final report of a trial of intensive versus standard blood-pressure control

The **SPRINT Research Group** randomly assigned 9361 participants who were at increased risk for cardiovascular disease but did not have diabetes or previous stroke to adhere to an intensive treatment target (systolic blood pressure < 120 mmHg) or a standard treatment target (systolic blood pressure < 140 mmHg. At a median of 3.33 years of follow-up, the rate of the primary outcome and all-cause mortality during the trial were significantly lower in the intensive-treatment group than in the standard-treatment group (rate of the primary outcome 1.77% per year vs. 2.40% per year, hazard ratio 0.73, 95% confidence interval [95%CI] 0.63–0.86, all-cause mortality 1.06% per year vs. 1.41% per year, hazard ratio 0.75, 95%CI 0.61–0.92). Serious adverse events of hypotension, electrolyte abnormalities, acute kidney injury or failure, and syncope were significantly more frequent in the intensive-treatment group. When trial and post-trial follow-up data were combined (3.88 years in total), similar patterns were found for treatment benefit and adverse events; however, rates of heart failure no longer differed between the groups.

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