Original Research Article

Use of Cranial Computed Tomography(CT) in Elderly Patients Presenting after a Fall: Can We Predict Those Having Abnormal Head CT Scans

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Abstract:

Aims: Identify factors predictive of increased risk of intracranial injury and assess the ability of the non-age related components of the New Orleans head CT criteria (NOC) to guide decision-making.

Study Design: Retrospective electronic medical record review and application of decision rule

Place and Duration of Study: Emergency Department of Vidant Medical Center, Department of Emergency Medicine, Brody School of Medicine at East Carolina University; Greenville North Carolina, USA; January 2008 through December 2008

Methodology: Electronic Medical Records of patients > 65 years of age coming to our Emergency Department during 2008 with a diagnosis of fall or traumatic injury were reviewed. Demographics, fall/injury details, risk factors, CT performance, and CT findings were recorded. Revisit within 30 days was reviewed. Non-age related NOC were applied to the population. Transfers, known intracranial injury, and multisystem trauma were excluded. Independent predictors of positive findings were sought using logistic regression.

Results: 783 patients with fall and traumatic injury were identified. Ninety-six met exclusion criteria, leaving 687 for analysis. 321 patients received head CT; 296 met the non-age NOC for head CT. Twelve (3.1%) abnormal head CTs were identified; nine showed an acute finding. Acute findings were not predicted by any independent variable. All 12 of the abnormal head CTs (9 acute, 3 chronic) were identified by the non-age NOC. 45 patients presented again within 30 days with no injuries noted.

Conclusion: Age over 65 did not increase the risk for acutely abnormal head CT in the patient presenting to the ED after a fall. No single factor was predictive of acutely abnormal head CT. The use of the non-age related NOC predicted those patients having an abnormal head CT with 100% accuracy. Age may not independently necessitate head CT after a fall.

Key Words: elderly, fall, head injury, computed tomography, decision rules

INTRODUCTION

In 2004, injuries resulted in 31 million emergency department (ED) visits, representing 32% of all visits. Elder patients are at highest risk for both fatal and nonfatal injuries with mortality and hospitalization rates for injuries reported to increase dramatically.[1,2]. Falls are the most common mechanism of injury for older patients visiting the ED and are the most common cause of injury-related death [1,2]. Several widely used evidence based decision rules [3-10] using a general population indicate that age over 60 or 65 years places the patient at high risk for an abnormal head CT after a mild head injury. The various decision rules have been compared to determine if one more readily differentiates the patient who will benefit from head CT [11-13], but none specifically address only the population of patients over age 65 who potentially have an intracranial injury, particularly after a fall. Currently no definitive evidence exists as to how to evaluate elderly patients after a fall. Due to the general increased incidence of injury, and specifically closed head injury, head CT is frequently ordered [14]. However, CT scans are costly and are now recognized to carry a radiation risk [15, 16].

Head CTs ordered because of a fall account for the expenditure of millions of dollars annually in the United States [3]. To contain costs while providing excellent care, it is important for emergency physicians to know if patients will benefit from head CT. We retrospectively searched for elderly patients who fell and are considered at increased risk for intracranial injury, based upon current decision-making strategies. We sought to define risk factors for acutely abnormal head CT in these elder patients after a fall, as it is the most common mechanism of mild blunt closed head injury and applied the non-age related NOC to the population receiving head CT scans. We hypothesized that application of the non age NOC to the elderly population will reduce the head CTs ordered in this population without compromising care.

MATERIAL AND METHODS

The study was conducted in the ED of a teaching hospital and Level I Trauma Center in the Southeastern United States with an annual census of 90,000 patients during 2008. All patients greater than 65 years of age presenting to the ED or its Fast Track area from January 1, 2008 to December 31, 2008 with ICD-9 code for “fall” or “traumatic injury” (958.0-959.0) as the final diagnosis were eligible for inclusion. Patients under 65 years of age, those received in transfer from another medical facility or accepted as a patient with multi-system trauma were excluded from analysis. Physician judgment and standard accepted medical practice determined whether a patient received a head CT scan. Prior to collection of study data, ten charts were randomly selected and all investigators extracted the prescribed data from each chart. Comparisons of the data obtained by each investigator were made to assess consistency in interpretation of patient records and findings. The kappa statistic for inter-rater reliability was

0.86 and demonstrated good reliability. EMR were retrospectively reviewed by three of the investigators (JB, RJ,CB) and data collected on a standardized form. Two investigators (NN, MA) applied the non-age NOC to the study population (Table 1).

Table 1: New Orleans Head CT rules: Presence of any of the following indicates the need for head CT [6]:

- Trauma above the clavicles
- Altered memory
- Intoxication
- Headache
- Vomiting
- Seizure activity
- Age > 60 years (N/A in this study)

The following data was collected: age, gender, type of fall, presence of dementia, anticoagulant or aspirin use, presence of/type of injury above the clavicle, performance of head CT, acute finding on head CT, return within 30 days, reason for return, head CT at return visit, and acute findings present at return visit. Type of fall was characterized as: fall from bed, from sitting, from standing or from height above ground. Dementia was noted from the patient's past medical history or the current provider's note. A patient was considered to have a memory deficit if they had a change from their baseline memory status. Headache was any reported head pain, localized or diffuse. Intoxication was determined as per the treating physician's documentation. If intoxication was not reported then the patient was deemed not intoxicated. Seizure activity included any suggestion of seizure. Anticoagulants were categorized as: aspirin, clopidogrel, warfarin, fractional based or low molecular weight heparin. Presence, location, and type of injury were noted from the physician's note and the discharge or admission diagnoses recorded in the chart for that visit. Trauma above the clavicles was considered as any physical evidence of trauma above the clavicles. Vomiting was present if noted in the chart. If the treating physician was unable to obtain any information it was noted as "unable to obtain". Radiologists' official readings were used to assess presence of abnormal head CT. The word "acute" needed to appear in the radiology report describing the intracranial findings for the image to be considered "positive". The NOC were first applied to the positive scans to determine if they would have been detected using the rules. The same rules were applied to patients with normal head CT scans to evaluate for potential reduction, if any, in total head CTs ordered. Neither cognitive nor psychometric testing was performed due to the retrospective nature of the investigation. Consensus among abstractors regarding collection and recording was reached by periodic discussions as needed.

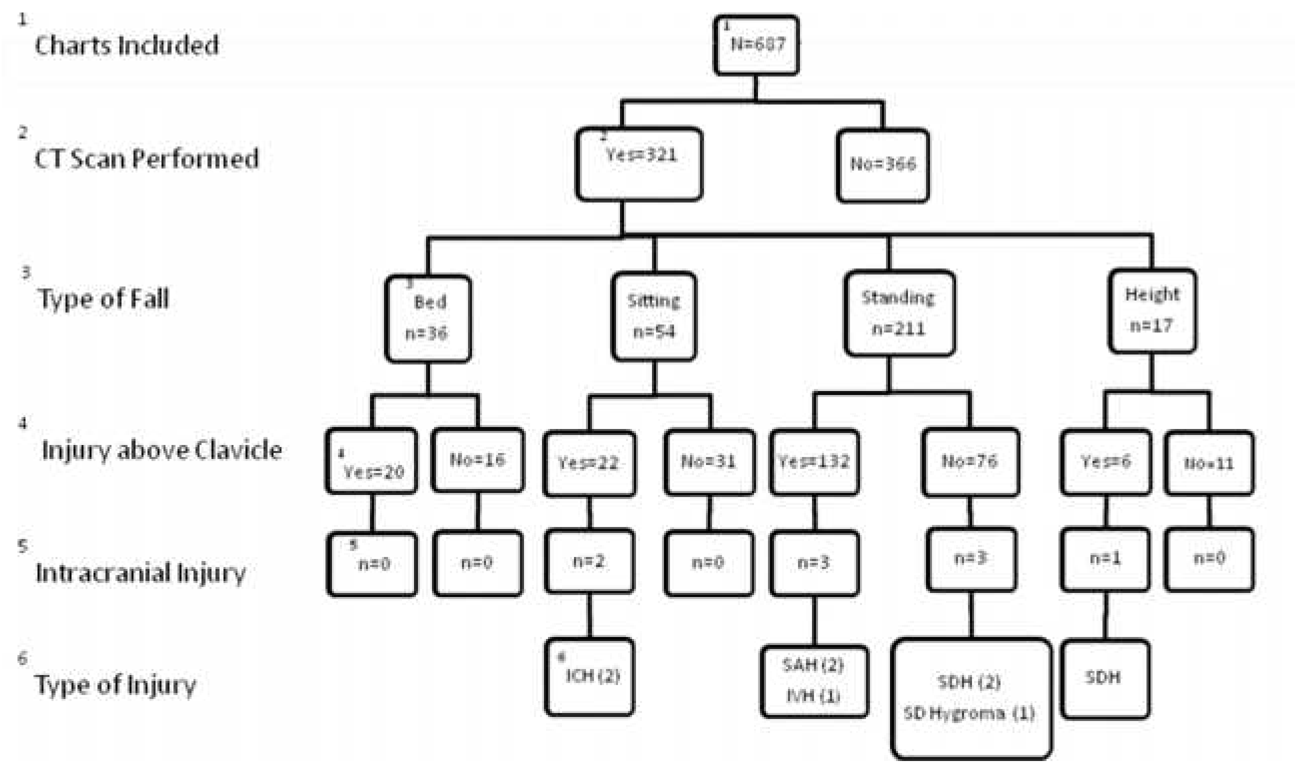
Chi square analysis was used for the dichotomous variables of gender, presence of dementia, anticoagulant use, type of fall, and injury above the clavicle. Regression analysis was used to determine if any of the historical or physical examination variables were independent predictors of intracranial injury. Statistical analysis was performed using STATVIEW (SAS, Inc). This study, UMCIRB #08-0773, was reviewed and deemed exempt by the University and Medical Center Office for Human Research Integrity.

RESULTS

Patients ranged in age from 65 to 98 years. Out of 687 reported falls, 321 cranial CTs were performed (46.4%). The mean age of patients receiving head CT after fall was 81.4 years (range 65-98). No difference in age existed between those with acute intracranial findings vs. those without acute findings (P= .67). Only 9 (2.8%) of the 321 scans showed evidence of acute intracranial injury (Figure 1) with 33 extra-cranial findings noted: scalp hematoma (n=16), soft tissue edema (n=7), sinusitis (n=5), facial/orbital fracture (n=4), and cervical spine injury (n=1).

Two stable/chronic subdural hematomas and one stable hygroma were noted making twelve patients with abnormal CT scans. Of the acute intracranial injuries, none required neurosurgical intervention but 7 (78%) were admitted to the hospital for physical, occupational, or speech therapy. Two were made Do Not Resuscitate by family members.

Figure 1:



Forty-five patients presented again within 30 days, primarily for wound checks. No new abnormal CT scans were noted upon return visit. 67% (6 of 9) of the intracranial injuries occurred in patients with visible injury above the clavicles, although this did not prove to be an independent predictor of acute CT findings (p=.20). None of the independent variables were predictive of acutely abnormal head CT (Table 2).

Table 2: Comparison of patients with positive CT findings vs. patients with no acute CT findings

Variable	No Findings on CT	Acute Findings on CT	P-value
Age (years)	80.0±7.7	81.3±8.3	.67
Gender	79% Female	67% Female	.41
Presence of Dementia	141 (44.0%)	4 (1.8%)	.40
Aspirin Use	149 (46.7%)	6 (1.9%)	.41
Injury above clavicle	189 (58.9%)	6 (1.9%)	.20
Fall from Bed	36 (11.3%)	0 (0%)	.31
Fall from Sitting	52 (16.3%)	2 (0.6%)	.19
Fall from Standing	205 (64.5%)	6 (1.9%)	.68

Fall from Height	16 (5.0%)	1 (0.3%)	.52

Using the non-age items of the NOC, EMR of 296 patients receiving head CTs were able to be reviewed. 123 (45%) had a history of dementia. Only 36 (15%) of the 238 patients in whom complete events about the fall were ascertained were reported to have had alteration of consciousness. All twelve of the patients with abnormal head CTs (9 acute, 3 chronic) were identified by application of the non-age NOC. (Table 3)

Table 3: Non-age Related New Orleans Head CT Rules Patient Findings

	No Acute Head CT Abnormalities			Total Head CT abnormalities		
	Total	N#	%	Total	N	%
Trauma above the clavicles	174	284	61	11	12	92
Altered memory	12 *	281	4	3	12	25
Intoxication	11	284	4	1	12	8
Headache	80	246	33	6	11	55
Vomiting	9	257	4	0	12	0.0
Seizure Activity	1	255	0.3	1	12	8

#Total number of responses different based on ability of physician to obtain information from patient or witnesses

*1 patient with impaired short term memory, 3 patients with newly diagnosed confusion, 6 Patients with worsening of baseline confusion, 3 patients with unknown baseline mental status

The finding most frequently associated with abnormal head CT was trauma above the clavicle. Strict application of the non-age NOC to this population would have reduced the number of patients receiving head CTs by 20% without missing any abnormal head CTs (Table 4).

Table 4: Reduction of Head CT scans by patient history and attributes

	Calculated reduction in Head CT Scans under Each Condition	
	All Patients N=296	Patients with Abnormal Head CT scans N=12

New Orleans Head CT rules **Alone**	59 (20%)	0
New Orleans Head CT rules, **Adding** History of Dementia	32 (10%)	0
New Orleans Head CT rules , **Adding** Fall from height and Anticoagulation	48 (16%)	0
New Orleans Head CT rules, **Adding** Fall from height, Anticoagulation and History of Dementia	24 (8%)	0

*If information was unable to be obtained from a patient the patient was considered to require a head CT scan for further evaluation

Addition of dementia, fall from height, or current anticoagulation therapy to the non-age NOC produced a lesser reduction in CT scans ranging from 8-16% as shown in Table 4 above. Data for antiplatelet and anticoagulation therapy are shown in Table 5.

Table 5: Anticoagulation and Antiplatelet Therapy

	No Acute Abnormality N=284	Total Head CT Abnormalities N=12	P
Antiplatelet Therapy*	147 (52%)	9 (75%)	.24
Anticoagulation Therapy#	33 (12%)	1 (8%)	.79

*Aspirin or Plavix Therapy
Warfarin or Heparin product

DISCUSSION

Clinical decision rules often use age as an exclusion criterion due to a higher reported incidence of injury in elderly adults, contributing to a significant amount of cranial imaging in this population with mostly negative results [17]. It will be important to better define the population of elderly patients in whom imaging may not be necessary after a fall. Much work has been done regarding decision-making and whether a patient is at high, medium, or low risk for intracranial injury after a minor head injury. All have concluded that age of >60-65 years places the patient at high risk and recommend imaging [3-10]. None have attempted to isolate the population of patients over age 65 years who have an apparent minor head injury.

Neurosurgical significance is frequently used in descriptions of primary outcome measures involving a range of 0.1% to 6% as well as clinically important brain injury ranging from 6% to 15-20%. Our study population had a neurosurgical intervention rate of 0%, with 78% of the injuries judged clinically important based upon information from Stiell and colleagues [18].

While the incidence of falls in our study was consistent with epidemiological reports, we found a low incidence (2.8%) of positive scans. Our selected clinical variables were identical to those included in all the studies cited and included additional variables specific to the elderly population (anticoagulation and dementia). None of the independent variables we selected proved to be associated with abnormal head CT, either due to the mechanism of simple fall and its associated low kinetic energy or the low number of positive scans. Injury above the clavicle was closest to reaching statistical significance. A post-hoc power analysis indicated that 45 positive scans would be needed to make this a significant predictor at(P=.05) with 90% power and an additional 1650 scans or approximately 4 to 5 years of patient EMR would need to be assessed. Our small number of positive findings is consistent with other studies involving minor head injuries [6, 19], reiterating the low frequency of abnormal head CT scans in patients with minor head injuries and emphasizing that abnormal head CT resulting from falls is rare. The majority of patients in our study had no alteration of consciousness and were at their baseline mental status when they presented to the ED. These findings have been shown to be good prognostic factors in patients with minor head injuries [19].

One goal of this study was to evaluate if the non-age NOC are effective when used with elderly patients presenting after falls. Using the intention to treat model, when components of the NOC were unable to be obtained, the patients required a head CT scan. When the non-age NOC were applied to patients with abnormal head CT scans, all were detected. If these components of the NOC had been strictly applied to the population at presentation there would have been 20% fewer head CT scans ordered. This reduction is highly dependent upon obtaining reliable histories from patients or witnesses for patients with dementia; admittedly a major difficulty for physicians. A large number (46%) of patients had dementia and the NOC could be applied to a significant number of patients in this study with severe dementia only with the contribution of witnesses, as the patient was unable to provide details of the fall. Fortunately, the components of the NOC were able to be obtained for 64% of patients with dementia. Patients or caregivers were able to describe events during or after the fall, as well as relate current mental status to baseline mental status. With the low number of abnormal head CT scans we further evaluated the NOC performance by incorporating high-risk patients. Nagurney et al [20] showed that elderly patients fall from a height or down stairs less frequently but these falls are more likely to result in abnormal head CT scans. The effect of anticoagulation on the likelihood of abnormal head CT scan is less clear [21-23]. Our data found no increased frequency of abnormal head CT in patients taking anticoagulant therapy. When the patients on anticoagulation therapy or with falls from a height are excluded and the NOC applied, there is a modest 16% reduction in head CT. If all patients with dementia are excluded from consideration and scanned, there is only an 8% reduction in head CT scans ordered.

In the major studies and recommendations, some period of altered consciousness has been used as an indicator of head injury. Our study found that momentary alteration of neurological function may not be a sufficient indicator of head injury. Only a minority of patients had alteration in consciousness (15%), however 50% (6 of 12) of patients found to have abnormal head CT did not report any alteration in consciousness. Therefore, alteration in consciousness was not useful in determining if imaging was needed; a finding that only adds to the current lack of clarity when evaluating elderly patients for head injury. An acutely abnormal head CT may be present despite not having a period of altered consciousness used to clinically define head injury. All elderly patients that present after trauma should be carefully assessed clinically for signs of intracranial injury. These findings will guide whether to obtain imaging in their evaluation. Among our physicians, dementia/inability to assess mental status, anticoagulation, and injury above the clavicles were the most common reasons cited for ordering head CT for an elderly patient with a fall. While 34% of those without dementia were scanned, 66% of those with dementia were scanned (P=.001). This difference held true for anticoagulation with aspirin (55% scanned on aspirin vs. 45% not on aspirin (P=.01) and injury above the clavicle (75% scanned with injury vs. 25% scanned without injury (P=.001)). However, none of these variables were predictive of intracranial injury.

As physicians, “The fear of failing to identify brain injury has led to the liberal and excessive use of CT scanning of patients with blunt head trauma who have even a remote possibility of intracranial injury” [5]. This is now coupled with concerns of cumulative radiation exposure to the individual patient. The use of any diagnostic modality needs to be justified by improving healthcare outcomes and the cost of medicine. This aspect of geriatric emergency medicine seems promising as an area of investigation. Evidence based guidelines are needed to provide assistance in the evaluation of elderly patients for acute intracranial injury after suffering a fall.

The low rate of positive findings in our study suggest an underpowered study, however it may simply reflect the mechanism of injury alone. Higher velocity injuries were included in the studies referenced, whereas this study limited the population to elderly patients with a simple fall. The number of visits and scans performed are still similar to those studies cited in the creation of the existing decision strategies yet the frequency and severity of injury was much less. Our finding of only 2.9% intracranial injuries is lower than previously reported and may simply reflect this different mechanism of injury. Our study included only patients with a simple fall, a very common source of injury in the elder population, whereas studies validating implementation of the published decision rules included patients incurring injury from high velocity injuries as well as patients under 65 years of age. Post-hoc power analysis revealed that an additional 1650 CT scans, approximately 4 to 5 years of patient EMR, would need to be reviewed to obtain significance in the variables analyzed at (P =.05) with 90% power.

Our data are therefore not intended to be generalizable to all ages of patients, those previously studied, or those with different mechanisms of injury. Patients living in long-term care facilities have been reported to have an increased risk of falling [19, 20]. We did not include "location of fall", such as nursing home, assisted living facility, personal home, or public place, and may have introduced selection bias against a patient with a higher level of independence. It is also possible that we did not capture everyone that sought fall-related medical care or presented again within 30 days after their ED discharge at the time of initial injury. The retrospective design precluded us from cognitively assessing patients for post concussive symptoms or conditions developing after 30 days. However, as the data collection began in the spring of 2009 and the last patient included was from December 31, 2008 as well as being the only hospital in the county and the primary regional referral source for our area of the state we feel that we would have detected all patients returning to our facility within 30 days of injury.

CONCLUSION

A low incidence of acutely abnormal head CT scans exists in the population of patients over 65 years of age after a fall. No single factor predicted the patient with an acutely abnormal head

CT. The non-age related components of the NOC predicted all (100%) of the patients that had an abnormal head CT; and if applied strictly would have decreased the number of head CTs ordered by 20%. Dementia, trauma above the clavicle, and anticoagulant usage by the patient were associated with performance of head CT by the emergency physician but not with the presence of intracranial injury.

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Authors' Contributions:

Charles K. Brown, MD: origination of the idea; assisted design of data collection instrument; data collection of single risk factors; manuscript preparation and submission; senior and corresponding author

Jennifer M. Bennett, MD: design of data collection instrument; data collection of single risk factors; manuscript preparation

Nathan R. Nehus, MD: application of the New Orleans Criteria to the data set; manuscript preparation

Matthew R. Astin, MD: application of the New Orleans Criteria to the data set; manuscript preparation

Reuben Johnson, MD: design of data collection instrument; data collection of single risk factors; manuscript preparation

Kori L. Brewer, PhD: assisted design of data collection instrument; data analysis; statistical analysis; manuscript, Table, and Figure preparation; assisted manuscript submission

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