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Diagnostic Study

Physical exam is not an accurate predictor of injury in geriatric patients with low-energy blunt trauma - A retrospective cohort study

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ABSTRACT

Background: When evaluating trauma patients, many centers perform computed tomography of the head, cervical spine, chest, abdomen, and pelvis, the so-called "pan-scan." Here, we evaluate the utility of physical exam against pan-scan in geriatric patients who sustained ground-level falls.

Methods: We performed a single-centered retrospective cohort review of consecutive patients from the trauma registry of a large, urban Level 1 trauma center. Inclusion criteria were registration during the 2019 calendar year, age ≥65, mechanism of fall from either sitting or standing, and performance of "pan-scan" at time of assessment. The sensitivity, specificity, positive and negative predictive values of the physical exam for significant injuries were calculated. The effect of such injuries on disposition from the emergency department and hospital were determined.

Results: An initial query for patients age ≥65 yielded 1280 patients. After exclusion of patients who did not undergo pan-scan or who had GCS <14, 751 patients were included in analysis. Median age was 84 years old. 351 patients had at least one injury identified on pan-scan. Physical exam was determined to have a sensitivity of 0.69 when compared to pan-scan as a gold standard. Patients with injury identified on CT scan had significantly more admissions, mortalities, and ICU and OR requirements.

Conclusion: Approximately half of all patients were found to have at least one injury on pan-scan. Physical examination was insensitive at identifying such injuries which ultimately altered patient management, disposition, and outcomes. Pan-scan is recommended in this vulnerable population.

1. Introduction

The elderly are the fastest-growing proportion of the population in the United States. According to the United States Census Bureau, between the years 2012 and 2050, the population of those aged 65 and older is expected to nearly double from an estimated 43.1 million to a projected 83.7 million [1]. Ground-level falls, which include falls from standing, sitting, or toileting, are the most common mechanisms of injury in these patients and account for nearly 2.5 million injured patients annually [2]. The number of patients aged 65–74 years old who experienced such ground-level falls has increased by 50.1% from 2001 to 2010 and by 33.1% in those 75 years and older [3].

In 2016, according to the National Trauma Data Bank, there were over 380,000 falls reported, and nearly 211,000 of those occurred in patients 65 years and older, comprising 55% of all falls [4]. This population is at an increased risk of falls due to age-related comorbidities such as visual impairment, gait disturbances, cognitive impairment, joint disease, and decreased agility. These factors all play a role in the geriatric patient's fall risk, as well as their inability to brace or protect themselves when falling. This makes them particularly susceptible to head and other injuries [5]. As the prevalence of the elderly population continues to increase, traumatic injuries due to falls will subsequently follow.

Computed Tomography (CT) utilization has surged in the last decade, with more than 80 million CT scans performed each year in the United States [3]. In the evaluation of the increasingly common geriatric trauma patient, many centers perform a CT of the head, cervical spine, chest, abdomen, and pelvis, the so-called "pan-scan." Whole-body CT has been effective in the workup of trauma patients because it has decreased time to diagnoses and treatment, effectively reducing mortality. However, whole-body CT has the disadvantage of increased radiation exposure and cost to the patient and hospital [6].

Evidence from observational studies of falls is conflicting. Studies that did not isolate the geriatric population suggest that the physical exam may be sensitive enough to select which patients do not require a pan-scan [2]. One study found only five abdominal and eight chest

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injuries were sustained in 14 out of 147 patients with falls from standing. All of these were noted on physical exam, suggesting the low yield of pan-scan in these patients [7]. Another study found that out of 349 fall patients who underwent abdominal CT, 93.4% of patients had no findings on CT imaging and did not undergo further intervention [8]. This large, multi-center study did not find a difference in mortality between those who underwent workup with pan-scan versus standard radiologic imaging in poly-trauma patients [8]. Support of universally pan-scanning geriatric patients has only recently been reflected in the trauma literature [1].

We set out to evaluate geriatric patients (≥65y) presenting to the emergency department (ED) with ground level falls. We hope to quantify and describe the injuries sustained as well as evaluate the diagnostic utility of physical exam when compared to CT scans of each the head, cervical spine, and chest/abdomen/pelvis both alone and combined as a “pan scan”. Finally, we hope to delineate the effect of such injuries on mortality, disposition, and other in-hospital outcomes.

2. Hypothesis

We hypothesized that for geriatric patients (≥65y) presenting to the emergency department with ground level falls (from sitting or standing), the physical exam can accurately select for patients who do not require a pan-scan. Given the fact that clinical findings are sufficient to both identify and rule out many thoracic and abdominal injuries, a targeted approach to imaging may be a more efficient use of resources. A tailored approach could potentially decrease the costs associated with extensive imaging, the number of incidental findings, and healthcare resource utilization as a whole.

3. Methods

A retrospective chart review was conducted using the trauma registry at a large, urban Level 1 trauma center. This registry was queried for consecutive elderly patients (age ≥65 years) who presented with fall from sitting or standing from 01/01/2019–12/31/2019. This trauma registry includes all patients of which the trauma surgery team was notified as part of the institution’s trauma notification protocol. It also includes patients who were ultimately admitted to the hospital with ICD 10 codes consistent with traumatic injuries, regardless of trauma team activation. Patients discharged from the Emergency Department with a traumatic injury may have limited data in the registry.

The software used to record the trauma registry database which was queried for the purposes of this study was TraumaOne, Lancet Technologies by ESO. Data extraction was accomplished by building a population which filtered for patients 65 and older and included one of the following external cause codes (E-codes): W00.0XXA Fall due to ice and snow, W01 Fall on same level from slipping, W03.XXXA other fall on same level due to collision with another person, W05 Fall from Non-Moving Wheelchair, nonmotorized scooter and motorized mobility scooter, W06.XXXA Fall from bed, W07.XXXA Fall from chair, W08.XXXA Fall from other furniture, W19.XXXA unspecified fall, and W18 other slipping, tripping and stumbling falls.

Inclusion criteria were all patients who met the search criteria for age and date range, as above, with a mechanism of ground-level fall. These were defined as falls from either seated or standing. Exclusion criteria included age <65 years, falls from height, GCS less than 14, and patients who did not undergo the complete pan-scan. Patient demographics, physical exam findings, trauma protocol pan-scan status/results, focused assessment with sonography in trauma (FAST) exam, injuries sustained, ED disposition, and outcomes were recorded.

Complete physical exam was the index test and was extracted from the EMR, as performed and documented by emergency department and/or admitting physicians. This includes a detailed primary and secondary survey. External signs of trauma were tabulated and classified by body region, either head, cervical spine, and chest/abdomen/pelvis for direct comparison to the different components of the CT “pan scan”. Positive findings were defined as any physical exam finding attributable to trauma including, but not limited to tenderness, deformity, lacerations, abrasions, and ecchymosis. Any finding outside of normal, negative findings listed in physical exam documentation was considered positive. CT findings were ultimately available to ED, trauma, and admitting providers, but were performed after primary and secondary survey in accordance with Advanced Trauma Life Support (ATLS) protocol.

The trauma protocol “pan-scan” was used as the gold standard for comparison. This was implemented as a non-contrast CT of the head and cervical spine, and CT with intravenous contrast of the chest, abdomen, and pelvis with both venous phase and noncontrasted images. Injuries were identified by ICD 10 codes which were also included in the trauma registry. These codes were correlated with CT pan scan findings; any diagnosis which was not seen on CT and documented in the report was excluded. Positive findings were those considered by the radiologist to be attributed to trauma and included in ICD-10 diagnoses attributed to a given patient; therefore, no indeterminate CT findings recorded for the purposes of this study. Physical exam findings were available to radiologists. Time to CT was not recorded, but as per protocol, was performed based on level of trauma activation and stability of patient.

This study was registered with the IRB at Staten Island University Hospital (study number 20-0850-SIUHN) and was granted exempt status due to its retrospective chart review nature. Study design was carried out in accordance with the Enhancing the QUAlity and Transperency of health Research (EQUATOR) Guidelines. Specifically regarding the guideline for reporting on studies of diagnostic accuracy, this study adheres to the format of the Standards for Reporting Diagnostic Accuracy (STARD) 2015 guidelines as well as the Strengthening the Reporting of Cohort, Cross-Sectional, and Case-Control Studies in Surgery (STROCSS) 2021 criteria [9]. This work was registered with both Clinicaltrials.gov (Identifier: NCT05409001) as well as Researchregistry.com (Unique Identifying Number: researchregistry8214) https://www.researchregistry.com/browse-the-registry#home/registrationdetails/62fe983272ae51002218b469/

Data were analyzed using SAS software (Statistical Analysis Systems Inc., Cary, NC, USA). Mean ± standard deviation (SD) was used to report quantitative data, and frequency and percentage were reported for qualitative data. The sensitivity, specificity, and positive and negative predictive values for physical examination were computed using CT scan as the gold standard. To compare proportions and evaluate agreement between physical examination and CT scans, McNemar chi-square test was employed. P-values under 0.05 were considered statistically significant. Intended sample was determined to be greater than 500 patients, as determined by the investigators’ prior knowledge of annual trauma admissions and CT utilization, as well as its sufficiency for the aforementioned statistical analysis.

4. Results

An initial query for patients age ≥65 with fall mechanism yielded 1280 patients. Four hundred eighty-eight patients were excluded due to lack of a complete pan-scan. No patients in the database lacked a physical exam. Twenty-nine patients were excluded due to GCS <14 as recorded in the trauma database. An additional 12 patients were excluded due to GCS <14 after in-depth chart review. Seven hundred fifty one patients were included in the final analysis (Fig. 1).

Median age was 84 years old. 269 (36%) were male and 482 (64%) were female. One hundred fifty-nine patients carried a concomitant diagnosis of dementia (Table 1). The majority of traumatic injuries identified were fractures, followed by contusions, lacerations, and abrasions; anatomical locations of these injuries most commonly involved the long bones, followed by the pelvis, and ribs (Fig. 2).

Of 751 total pan-scans, 351 (46.8%) were positive for at least one significant injury and 400 (53.2%) were negative overall. Of 351 positive pan scans, 53 patients had at least one positive finding on CT of the

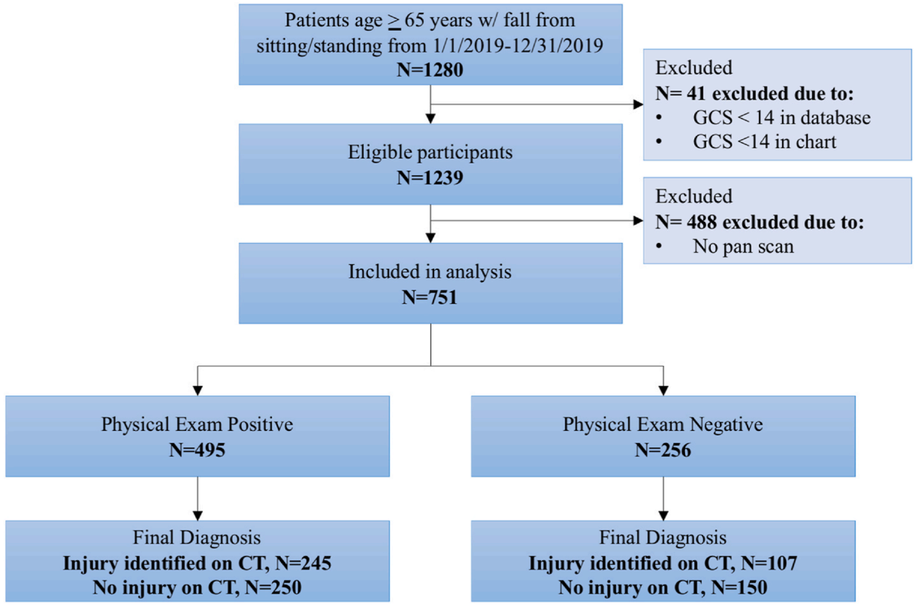

Fig. 1. Patient selection.

Table 1
Baseline patient demographics and injuries.

	Pan-scan positive N = 351	Pan-scan negative N = 400	*p*-value
Demographics			
Sex, n (%)			
Male	113 (32.2)	156 (39.0)	0.0567
Mean Age (± SD)	83.9 (±8.3)	82.8 (±8.3)	0.0586
Dementia, n (%)	77 (21.9)	81 (20.25)	0.5911
Injury			
Injury Severity Score, median (IQR)	9 (4,10)	2 (1, 5)	<.0001
Glascow coma score			
GCS = 15, n (%)	336 (95.7)	378 (94.5)	0.5009

head, 35 had at least one positive finding on CT of the cervical spine, and 296 had at least one positive finding on CT of the chest/abdomen/pelvis when distributed by radiology report.

Physical exam results for those with positive CT findings are listed in Table 2; of the 351 patients with positive imaging findings, 244 (69.6%) had positive physical exam findings. False negative rates for physical exam ranged from 37.7% for head injuries to 80% for injuries to the cervical spine. When compared to CT scan as the gold standard diagnostic tool for traumatic injury in the elderly, physical exam was determined to have a sensitivity of 0.62, 0.20, and 0.20, and 0.69 for CT head, c-spine, chest/abdomen/pelvis and pan-scan, respectively. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of physical exam for detecting significant injury are listed in Table 3.

Disposition of patients was determined both initially from the emergency department and ultimately at the time of hospital discharge, as represented by Tables 4 and 5, respectively. Patients with injury identified on CT scan were significantly more likely to require management of their findings, including hospital admissions, ICU admissions, and operative management. In addition, patients with injuries identified on CT who initially underwent admission, where subsequently more likely to be discharged to inpatient rehabilitation, or to have expired. No adverse events from performing physical exam or CT pan scan were reported.

5. Discussion

Whole-body scanning can be advantageous in identifying occult injuries in asymptomatic patients, such as abdominal injuries in the setting of other distracting injuries, such as soft tissue wounds and rib fractures [10]. However, widespread use of pan-scan for low-energy blunt trauma has not yet been borne out in the trauma literature, at least as it pertains to the chest, abdomen and pelvis.

In our study, we found that most injuries consisted of fractures, specifically those involving the long bones followed by the pelvis, then the ribs. Other non-fracture injuries included contusions and abrasions, but visceral organ injuries were not a common finding, which is consistent with existing literature.

CT scans of the head may be of greater utility than that of other body regions. While the incidence of intracranial findings may be low, the consequences of such injuries are great. One study demonstrated intracranial abnormalities in 8% of elderly trauma patients, with mortality rates described ranging from 0.3% to as high as 24% [12]. Another identified 38 out of 500 patients with subdural and subarachnoid hematomas, 3 of whom had indications for surgical management [13]. Similarly, our results demonstrate CT findings of head injury in 53 out of 751 patients (7.1%). Of these, physical exam had a false negative rate of 37.7%.

Cervical spine injuries occur in about 3.7% of trauma patients [14]. In our study, we identified 35 (4.7%) patients with cervical spinous injury on CT. We attribute this increase in incidence to the multitude of risk factors that plague the elderly, including their inability to protect themselves during a fall [5]. Therefore, CT head and C-spine should still be commonly employed to rule out any intracranial or cervical spinous injuries, due to their clinical significance and need for management [15]. Other forms of imaging such as x-ray have a limited role in the detection of vertebral fractures, and CT is still the modality of choice. Our data further reveals a false negative rate of 80% for the detection of cervical injuries by physical exam.

During secondary assessment of the chest, abdomen, and pelvis, both physical exam and adjuncts such as FAST examinations can help identify injuries. However, these may be misleading and nonspecific in determining internal trauma. According to the study by Hagan et al., FAST exams in blunt abdominal trauma had a 31% false-negative rate. In this retrospective study of patients with ground-level falls, 12.5% were found to have sustained an abdominal injury and 23% had a chest

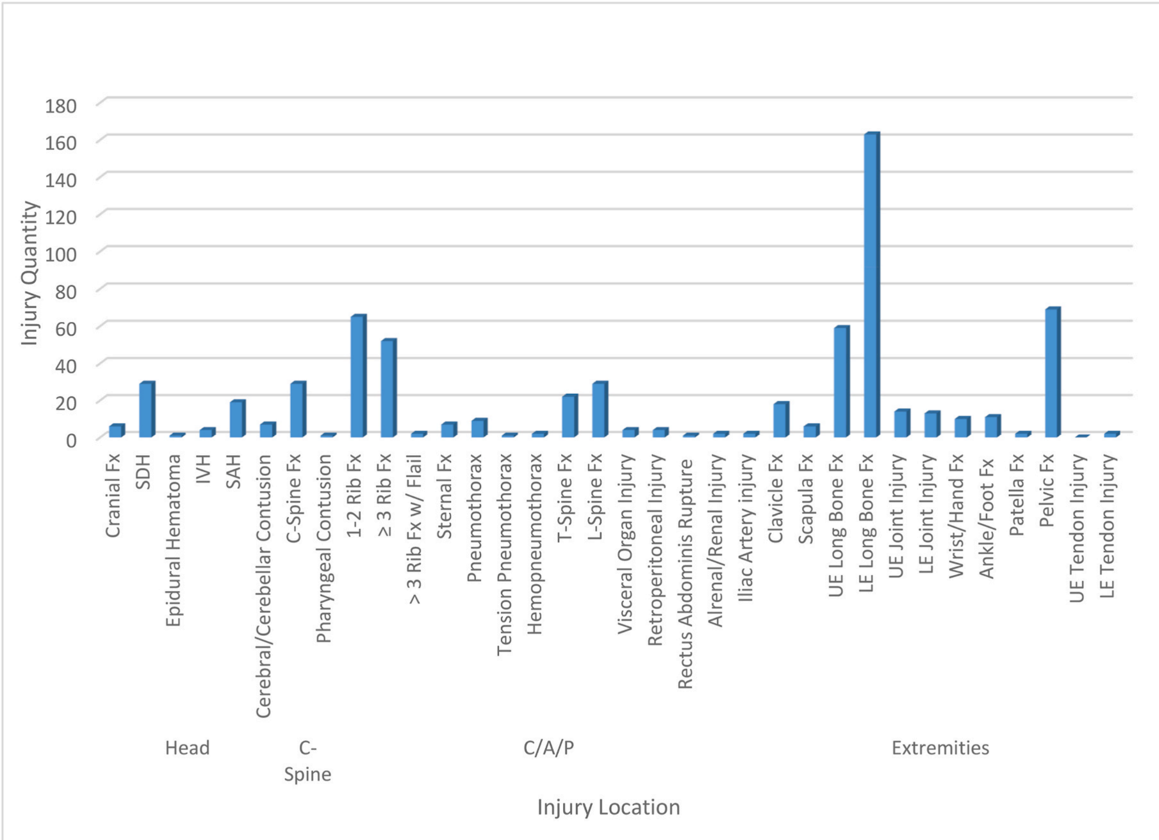

Fig. 2. Injuries by body region. Fx = Fracture, SDH = Subdural Hemorrhage, IVH = Intraventricular Hemorrhage, SAH = Subarachnoid Hemorrhage, T-Spine = Thoracic Spine, L-Spine = Lumbar Spine, UE = Upper Extremity, LE = Lower Extremity.

Table 2
Physical exam findings in those with positive computed tomography by body region.

	Positive PE (%)	Negative PE (%)
Head CT, n = 53	33 (62.3)	20 (37.7)
C-Spine CT, n = 35	7 (20.0)	28 (80.0)
C/A/P CT, n = 296	174 (58.8)	122 (41.2)
Pan-scan, n = 351	244(69.5)	107 (30.5)

PE= Physical exam, CT= Computed tomography, C/A/P= Chest, abdomen, and pelvis.

Table 3
Sensitivity, specificity, positive- and negative-predictive values of physical exam for identifying.

	PE Sensitivity	PE Specificity	PE PPV	PE NPV
Total Pan-scan	0.6960	0.3750	0.4949	0.5837
Head	0.6226	0.6490	0.1187	0.9577
C-Spine	0.2000	0.9651	0.2188	0.9611
C/A/P	0.6960	0.3750	0.4949	0.5837

PE= Physical exam, PPV= Positive predictive value, NPV= Negative predictive value, C-Spine = Cervical spine, C/A/P= Chest, abdomen, and pelvis.

Table 4
Emergency department disposition, divided by those patients who has injuries identified by pan-scan vs. those who did not.

	Pan-scan positive N = 351	Pan-scan negative N = 400	*p*-value
Emergency department disposition			
Non-admissions, n (%)	19 (5.4)	136 (34)	<.0001
Left AMA	1 (0.3)	3 (0.8)	0.6272
Home without services	17 (4.8)	131 (32.8)	<.0001
Other (jail, institutional care, mental health, etc.)	0 (0.0)	1 (0.3)	1.0000
Transferred to another hospital	1 (0.3)	1 (0.3)	1.0000
Hospital Admissions, n (%)	332 (94.6)	264 (66.0)	<.0001
Observation unit (unit that provides <24 hour stays)	20 (5.7)	17 (4.3)	0.4005
Floor bed (general admission, non-specialty unit bed)	183 (52.1)	164 (41.0)	0.0026
Telemetry/step-down unit	38 (10.8)	60 (15.0)	0.1034
Intensive Care Unit (ICU)	75 (21.37)	17 (4.25)	<.0001
Operating Room	16 (4.6)	6 (1.5)	0.0162

AMA = Against medical advice.

injury, all despite normal physical exams [11].

The use of physical exam in detecting intraabdominal hemorrhage after blunt trauma was found to have a sensitivity and specificity of 39 and 90%, respectively [16]. Our results demonstrate a 41.2% false negative rate, 69.6% sensitivity, and 37.5% specificity. This highlights the lack of sensitivity in relying on these means when determining the indication for imaging. A selective algorithm for CT of the chest, abdomen, and pelvis was found to reduce their use by 26% in patients that were hemodynamically stable and had a negative FAST examination [17]. We emphasize, however, the majority of injuries identified on CT were bony fractures, which are not necessarily associated with findings on FAST examination.

Our study has certain limitations. We used data which was collected retrospectively and included patients identified in the institutional trauma registry. Patients discharged from the Emergency Department with a traumatic mechanism and no activation of the trauma team may

Table 5
Hospital discharge disposition, divided by those patients who has injuries identified by pan-scan vs. those who did not.

	Pan-scan positive N = 332	Pan-scan negative N = 264	*p*-value
Hospital discharge disposition			
Left AMA or discontinued care, n (%)	0 (0.0)	3 (1.1)	0.0864
Discharged to home or self-care, n (%)	75 (22.6)	81 (30.7)	0.0308
Discharged to home under supervised care, n (%)	42 (12.7)	54 (20.5)	0.0133
Discharged to skilled nursing facility, n (%)	89 (26.8)	65 (24.6)	0.5727
Discharged to sub-acute rehabilitation, n (%)	23 (6.9)	15 (5.7)	0.6141
Discharged to inpatient rehab unit, n (%)	81 (24.4)	33 (12.5)	0.0002
Discharged to an intermediate care facility, n (%)	0 0.0)	2 (0.8)	0.1958
Discharged to a short-term general hospital, n (%)	1 (0.3)	0 (0.0)	1.0
Discharged to hospice care, n (%)	3 (0.9)	6 (2.3)	0.1943
Expired, n (%)	17 (4.8)	5 (1.3)	0.0042
Not recorded, n (%)	0 (0.0)	0 (0.0)	1.0

AMA = Against medical advice.

have limited data in the registry, which may skew data toward the more severely injured. Patients who did not receive all components of the pan scan were excluded from the study, which may have also decreased the proportion of uninjured patients. Physical exam data for patients was taken from provider notes in the electronic medical record (EMR). The volume of patients and variability of providers may have caused provider-dependent inconsistencies in both performing physical examination as well as documenting findings in the EMR.

Our data does afford certain advantages, however. We offer a robust series of consecutive patients representing a broadly-generalizable cohort of the elderly. Our sample represents a wide variety of geriatric patients ranging from the independent to the ailing, and the newly retired to centenarians. Despite the excluded patients, those included underwent detailed documentation of their injuries as well as numerous patient-centered outcomes.

While the literature suggests that pan-scans in adults are not necessarily beneficial, data specific to the elderly are sparse. Our research supports whole-body scanning to omit overlooking any subclinical injury. Even minor bony injuries in the elderly can alter their hospital course and disposition, requiring intervention ranging from intensive care and mechanical ventilation to operative intervention [18]. Our findings include statistically significant differences between injured and non-injured patients in terms of their management and disposition on admission from the ED, as well as upon hospital discharge.

6. Conclusion

Increasingly selective use of pan-scans for low energy trauma in the elderly may not be beneficial. Geriatric patients are a uniquely vulnerable population who are not only increasingly represented in today's society, but require special attention and further investigation. Falls from sitting and standing are a common mechanism of injury in the elderly, and our data suggests that they result in injury in approximately half of all patients that undergo trauma evaluation and pan-scan.

Physical examination lacks sensitivity at identifying clinically significant injuries of the head, cervical spine, and chest, abdomen, and pelvis in geriatric patients who sustain ground-level falls. Similarly, the specificity, positive and negative predictive values are also inadequate in the setting of trauma.

Such injuries alter the disposition and level of care of the elderly both at the time of ED evaluation and at hospital discharge. At present, for the purposes of trauma evaluation, pan-scans may have an increased utility in this vulnerable population, especially if one is concerned about the reliability of a patient's history and physical examination.

Provenance and peer review

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Northwell Health Protocol Record 20-0850 SIUHN,

Falls From Sitting to Standing, is registered and will be posted on the ClinicalTrials.gov public website.

Research Registration Unique Identifying Number (UIN)

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Authors contribution

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Abdelhalim D. Draft manuscript preparation

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Hawkins, S. Study conception and design, analysis and interpretation of results, draft manuscript preparation

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Declaration of competing interest

The authors have no conflicts of interest to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amsu.2022.104503.

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