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CT pan-scanning versus targeted imaging among older adults after ground level falls

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ABSTRACT

Background Ground level falls (GLFs) among older adults are responsible for millions of injuries. Routine pan-scanning (CT imaging of the head, chest, abdomen and pelvis) is commonly employed; however, we lack robust evidence of its benefit. We investigated whether pan-scanning identifies a larger proportion of patients with significant injury or injury requiring procedural intervention and hypothesized resuscitation area findings—including radiographs, ultrasound, and external signs of injury—would detect these injuries.

Methods We queried our institutional trauma registry data for patients ≥65 years presenting to our level 1 trauma center after GLFs. Our primary outcome was injury requiring procedural intervention. LASSO (least absolute shrinkage and selection operator) regression models were fit using cross-validation to identify predictors of significant injury to the head, chest, and pelvis/lower extremity from patient characteristics and resuscitation area findings.

Results 598 patients were included, among whom 17% underwent pan-scan. External signs of injury were associated with increased odds of significant injury in the head (OR 1.12; 95% CI 1.08 to 1.16), chest (OR 1.50; 95% CI 1.45 to 1.46), and extremity/pelvis (OR 1.07; 95% CI 1.04 to 1.10). Chest (OR 1.18; 95% CI 1.14 to 1.23) and pelvic X-ray (OR 1.36; 95% CI 1.33 to 1.40) were also associated with increased odds of significant injury. 17 patients required procedural interventions for head injuries and 2 for the chest. No patients had a significant injury requiring any procedures for the abdomen.

Conclusions Our study suggests resuscitation area findings may direct targeted imaging in the chest and abdomen/pelvis, but whether individual risk and institutional burden associated with pan-scanning is outweighed by its ease requires further study.

Level of evidence, study type Prognostic and Epidemiological, Level IV.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Routine pan-scanning is common among older adults who experience ground level fall because external signs may not be reliable indicators of injury severity; however, there is a lack of robust evidence indicating pan-scans alter procedural management compared with targeted imaging.

WHAT THIS STUDY ADDS

⇒ Our findings suggest resuscitation area findings may direct targeted imaging to the chest and abdomen/pelvis in older adults who experience ground level fall, but were unreliable indicators of injury to the head/neck which may be CT imaged routinely.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our study implies that a targeted imaging approach of the torso may reduce the overutilization of pan-scans without compromising patient outcomes.

BACKGROUND

One-third of older adults (aged ≥65 years) in the USA experience at least one ground level fall annually. Already responsible for seven million annual injuries, the incidence of ground level falls is projected to rise with the aging population.[1–4] Routine pan-scanning (full-body CT imaging) is common among older adults because external signs may not be reliable indicators of injury severity.[5 6]

Past studies associate pan-scans with reduced time to diagnosis, shorter hospital length of stay, and improved diagnostic accuracy.[7–10] However, there is a lack of robust evidence indicating pan-scans alter procedural management compared with targeted imaging (imaging body regions with external signs of injury).[8–13] CT imaging that does not impact clinical management may contribute to increased healthcare expenditures and burden operational workflow, especially in resource-limited settings.[8 9 14 15] Although pan-scanning injured older adults has become more common, we lack consistent evidence indicating survival benefit or decreased incidence of missed injuries.

We aimed to analyze if pan-scanning, compared with targeted imaging, is associated with identifying a higher proportion of patients with significant injury, defined as Abbreviated Injury Scale (AIS) score ≥3 or injury requiring procedural intervention, among older adult patients who experience ground level falls. We hypothesized that pan-scanning would not be associated with detecting a higher proportion of patients with significant injuries, suggesting that external signs of injury should guide targeted CT imaging among older adults who experience ground level falls.

METHODS

Study population

We queried the institutional trauma registry for older adult patients aged ≥65 years presenting to our American College of Surgeons Committee on Trauma-verified level I trauma center after a

Table 1 Demographics, injury patterns, and outcomes for older adults who experienced ground level fall

	Pan-scan (n=104)	Targeted imaging (n=494)	SMD
Demographics			
Age, years, mean (SD)	84.1 (8.4)	82.8 (8.4)	0.15
Male, No. (%)	47 (45.2)	181 (36.6)	0.18
English-speaking, No. (%)	92 (88.5)	425 (86.0)	0.09
Unknown	0	1 (0.2)	
History of dementia, No. (%)	15 (14.4)	50 (10.1)	0.17
Unknown	4 (3.8)	11 (2.2)	
Blood alcohol>0.08 g/dL, No. (%)	3 (2.9)	12 (2.4)	0.03
Antiplatelet use, No. (%)	32 (30.8)	124 (25.1)	**0.24**
Unknown	8 (7.7)	18 (3.6)	
Anticoagulant use, No. (%)	29 (27.9)	109 (22.1)	**0.24**
Unknown	8 (7.7)	18 (3.6)	
Injury patterns			
Witnessed, No. (%)	21 (20.2)	89 (18.0)	**0.24**
Unknown	33 (31.7)	213 (43.1)	
Loss of consciousness, No. (%)	14 (13.5)	70 (14.2)	**0.45**
Unknown	34 (32.7)	71 (14.4)	
GCS<15, No. (%)	31 (29.8)	107 (21.7)	0.19
External signs of injury, No. (%)			
Head	47 (45.2)	226 (45.7)	0.01
Neck	10 (9.6)	46 (9.3)	0.01
Chest	45 (43.3)	121 (24.5)	**0.41**
Abdomen and pelvis	18 (17.3)	51 (10.3)	**0.20**
Back and flank	27 (26.0)	66 (13.4)	**0.32**
Extremity	47 (45.2)	240 (48.6)	0.07
AIS score 1–2			
Head	20 (19.2)	111 (22.5)	0.08
Face	24 (23.1)	119 (24.1)	0.02
Neck	0 (0.0)	1 (0.2)	0.06
Chest	14 (13.5)	36 (7.3)	**0.20**
Abdomen	6 (5.8)	8 (1.6)	**0.22**
Spine	16 (15.4)	39 (7.9)	**0.24**
Upper extremity	24 (23.1)	129 (26.1)	0.07
Lower extremity (including pelvis)	19 (18.3)	98 (19.8)	0.04
AIS score ≥3			
Head	16 (15.4)	75 (15.2)	0.01
Face	0	0	<0.001
Neck	0	0	<0.001
Chest	34 (32.7)	84 (17.0)	**0.37**
Abdomen	2 (1.9)	0 (0.0)	**0.20**
Spine	5 (4.8)	15 (3.0)	0.09
Upper extremity	0 (0.0)	3 (0.6)	0.11
Lower extremity (including pelvis)	7 (6.7)	43 (8.7)	0.07
Outcomes			
Hospital LOS, days, mean (SD)	4.1 (4.0)	3.5 (3.6)	0.17
Procedural intervention, No. (%)	12 (11.5)	106 (21.5)	**0.27**
Head	2 (1.9)	15 (3.0)	0.07
Neck (including cervical spine)	3 (2.9)	6 (1.2)	0.12
Chest	1 (1.0)	2 (0.4)	0.07
Spine (thoracic, lumbar, sacral)	0 (0.0)	6 (1.2)	0.16
Abdomen	0 (0.0)	0 (0.0)	<0.001
Pelvis	0 (0.0)	1 (0.2)	0.06
Extremity	6 (5.8)	76 (15.4)	**0.32**
Mortality, No. (%)	2 (1.9)	6 (1.2)	0.06
Follow-up CT imaging, No. (%)	5 (4.8)	25 (5.1)	0.01
Acute injury on follow-up CT imaging, No. (%)	1 (1.0)	5 (1.0)	<0.001

Bold face indicates significant effect size defined as SMD ≥0.2.
AIS, Abbreviated Injury Scale; GCS, Glasgow Coma Scale; Hospital LOS, hospital length of stay; SMD, standardized mean difference.

ground level fall between January 1, 2019, and December 31, 2019. Ground level fall was defined as any non-elevated fall from the standing or seated position. We excluded patients who were hemodynamically unstable, defined as systolic blood pressure <90 mm Hg, intubated prior to arrival, or found down. We divided our study population into patients who underwent a pan-scan defined as CT imaging of the head, neck, chest, abdomen and pelvis, versus targeted imaging. The classification of patients who underwent pan-scan versus targeted imaging was based only on index CT imaging. This study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines (online supplemental digital content 1).

Variables

Our primary outcome was significant injury requiring procedural intervention (online supplemental digital content 2). Secondary outcomes were hospital length of stay, mortality, any acute injury on CT imaging (online supplemental digital content 3)—a subset of whom had minor injury (AIS score 1–2) or significant injury (AIS score ≥3) in any body region—and acute injury identified on follow-up CT imaging. Of note, to be consistent with CT imaging, we grouped external signs of injury to the abdomen and pelvis together, but the trauma registry categorizes injuries to the pelvis in the lower extremity AIS. Follow-up CT imaging was defined as CT imaging to a previously unimaged body region during the hospitalization but after the index CT imaging during the initial resuscitation in the trauma bay.

Statistical analysis

For descriptive analysis, we report standardized mean differences (SMD) to estimate effect size differences between patients who underwent pan-scans versus targeted imaging. The SMD quantifies the size of difference relative to the variability between groups and is less affected by sample size compared with p values. The threshold for significance was SMD ≥0.2. Alternatively, we report our results with p values in the online supplemental digital content 5 and 6. We calculated the proportion of patients with resuscitation area findings—defined as external signs of injury eg (loss of consciousness (LOC), laceration, abrasion, and ecchymosis), injuries identified on chest and pelvic radiographs, and extended focused assessment with sonography in trauma (eFAST). We then delineated the proportion of patients who subsequently had injury diagnosed on CT or required procedural intervention.

For multivariable analysis, we fitted a logistic regression model to identify factors including demographics, injury characteristics, and external signs of injury associated with the decision to pan-scan. We then fitted least absolute shrinkage and selection operator (LASSO) regression models to identify predictors associated with significant injury to the head, chest, and lower extremity, defined as AIS score ≥3. We excluded the face, neck,

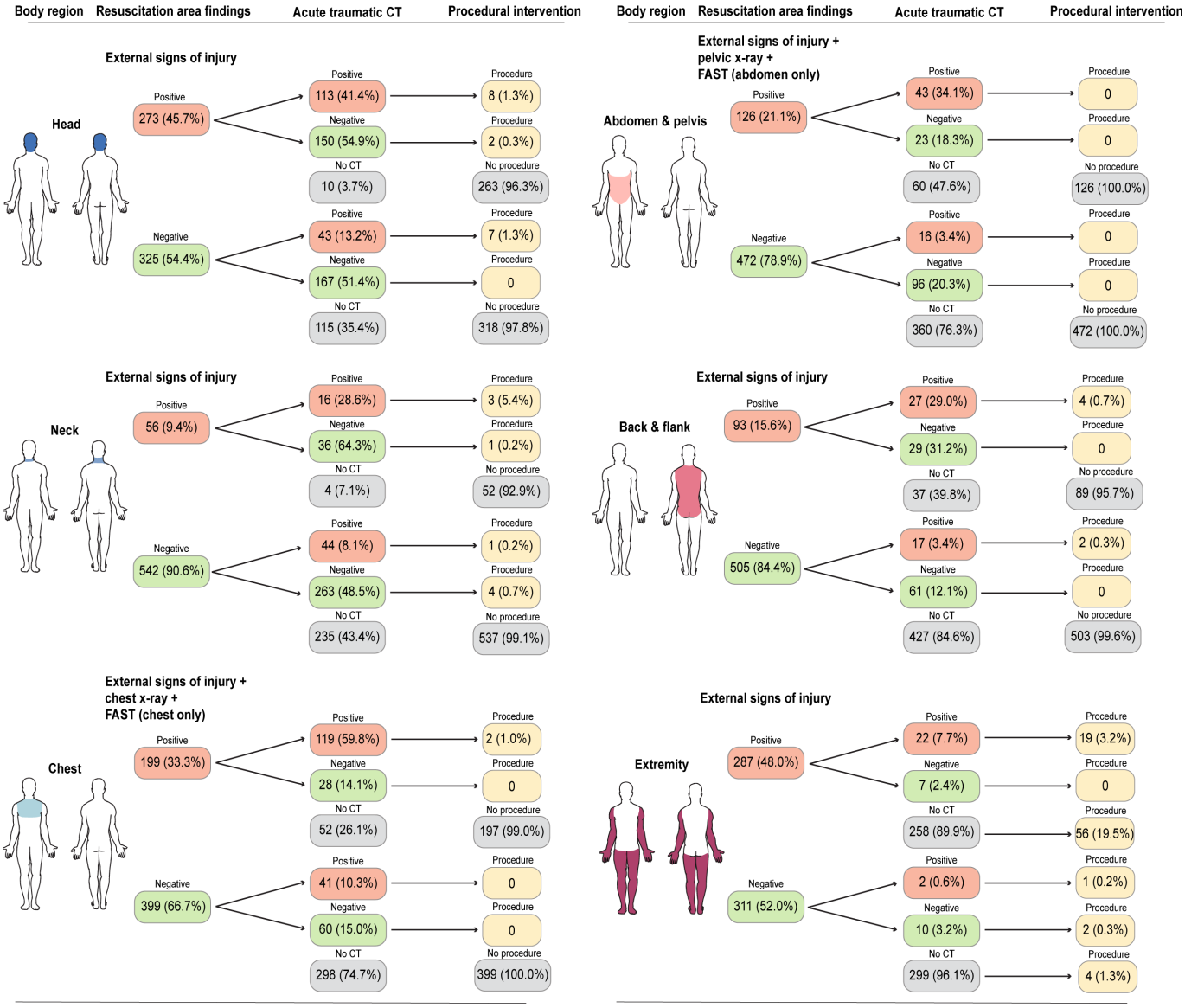

Figure 1 Proportion of older adult patients who experienced ground level fall with resuscitation area findings, acute injury on CT, and procedural intervention separated by body region. External signs of injury include any external sign of trauma such as abrasion, contusions, ecchymosis, laceration, deformity, or other sign. Acute traumatic CT includes any traumatic injury identified on CT imaging. Percentages are computed column-wise. FAST, focused assessment with sonography in trauma.

abdomen and pelvis, back and flank, and upper extremities from this analysis because <5% of our cohort had significant injury to these body regions. Using directed acyclic graphs, we defined candidate predictors to be demographic variables (age, sex), antiplatelet use, witnessed or unwitnessed fall, loss of consciousness, Glasgow Coma Scale (GCS), and body region specific external signs of injury and resuscitation area imaging (chest X-ray, pelvic X-ray, eFAST). To mitigate overfitting, 10-fold cross-validation was used to select lambda. We report ORs with 95% CIs. P value ≤0.016 was considered the threshold for statistical significance after Bonferroni correction for multiple hypothesis testing. All statistical analysis was completed using R statistical programming language V.4.1 (Vienna, Austria).

RESULTS

We identified 598 patients who experienced a ground level fall, among whom 104 (17%) underwent a pan-scan (table 1). A larger proportion of patients who underwent pan-scan used antiplatelet (31% vs 25%; SMD=0.24) or anticoagulant (28% vs 22%; SMD=0.24) medications. A similar proportion of patients had GCS<15 (30% vs 22%; SMD=0.19). A higher proportion of patients who underwent pan-scan had external signs of injury to the chest (43% vs 25%; SMD=0.41), abdomen and pelvis (17% vs 10%; SMD=0.20), and back and flank (26% vs 13%; SMD=0.32). A higher proportion of patients who underwent pan-scan had an AIS score of 1–2 in the thorax (14% vs 7%; SMD=0.20), abdomen (6% vs 2%; SMD=0.22), and spine (15% vs 8%; SMD=0.24) and a higher proportion of patients who underwent pan-scan had an AIS score ≥3 in the thorax (33% vs 17%; SMD=0.37) and abdomen (2 vs 0%; SMD=0.20), but a lower proportion of patients who underwent pan-scan underwent procedural intervention (12% vs 22%; SMD=0.27). Lastly, we found no difference in the proportion of patients who required follow-up CT imaging of a body region that did not undergo CT imaging on the index examination (5% vs 5%; SMD=0.01).

Table 2 LASSO regression models identifying predictors of significant injury (AIS score ≥3) to the head, chest, and lower extremity

	AIS score ≥3 head		AIS score ≥3 chest		AIS score ≥3 lower extremity (including pelvis)	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
Predictors						
Age	1.00 (0.96 to 1.04)	0.99	–	–	–	–
Male	1.07 (1.03 to 1.11)	<0.001*	–	–	0.98 (0.95 to 1.00)	0.10
Antiplatelet use	1.05 (1.01 to 1.09)	0.01*	–	–	1.00 (0.97 to 1.02)	0.82
Witnessed	–	–	–	–	0.97 (0.95 to 1.00)	0.06
Loss of consciousness	1.04 (1.00 to 1.08)	0.06	–	–	–	–
GCS	0.98 (0.94 to 1.01)	0.20	1.00 (0.96 to 1.04)	0.99	–	–
External signs of injury						–
Head	1.12 (1.08 to 1.16)	<0.001*	–	–	–	–
Neck	1.04 (1.00 to 1.08)	0.06	–	–	–	–
Chest	–	–	1.50 (1.45 to 1.56)	<0.001*	–	–
Extremity	–	–	–	–	1.07 (1.04 to 1.10)	<0.001*
Positive FAST	–	–	–	–	–	–
CXR	–	–	1.18 (1.14 to 1.23)	<0.001*	–	–
PXR	–	–	–	–	1.36 (1.33 to 1.40)	<0.001*

"–" excluded variables.
*Indicates statistical significance after Bonferroni correction for testing multiple hypotheses (p value ≤0.016).
AIS, Abbreviated Injury Scale; CXR, Chest X-ray; FAST, focused assessment with sonography in trauma; GCS, Glasgow Coma Scale; LASSO, least absolute shrinkage and selection operator; PXR, Pelvic X-ray.

To understand what factors were associated with the decision to pan-scan, we used multivariable logistic regression and found patients with unknown LOC (OR 3.00; 95% CI 1.63 to 5.50), external signs of injury to the chest (OR 2.34; 95% CI 1.45 to 3.77) or back and flank (OR 2.07; 95% CI 1.17 to 3.60) had increased odds of receiving pan-scan compared with targeted imaging (online supplemental digital content 4).

Figure 1 displays the proportion of patients with or without positive resuscitation area findings who subsequently had injury on CT or underwent procedural intervention (figure 1). Overall, 19% (n=116) of patients underwent procedural intervention for injury including 2.8% (n=17) for the head, 1.5% (n=9) for the neck, 0.3% (n=2) for the chest, 0 for the abdomen, 1.0% (n=6) for the spine, and 13.7% (n=82) for the extremity. Notably, both patients who underwent procedural intervention to the chest (n=2) had resuscitation area findings, and no patients in our cohort underwent procedural intervention for the abdomen. A higher proportion of patients had injury on head CT without resuscitation area findings compared with all other body regions (13.2% vs 5.4%; p<0.001). Further, a higher proportion of patients with injury on head CT without resuscitation area findings underwent procedural intervention compared with other body regions (2.2% vs 0.4%; p<0.001).

LASSO regression identified predictors associated with significant injury to the head, chest, and pelvis/lower extremity (table 2). For the head, we found male patients (OR 1.07; 95% CI 1.03 to 1.11; p<0.001), taking antiplatelet medications (OR 1.05; 95% CI 1.01 to 1.09; p=0.01), and external signs of injury to the head (OR 1.11; 95% CI 1.08 to 1.14; p<0.001) had increased odds of significant injury. For the chest, external signs of injury to the chest (OR 1.50; 95% CI 1.45 to 1.56; p<0.001), and positive chest X-ray (OR 1.18; 95% CI 1.14 to 1.23; p<0.001) had increased odds of significant injury. Lastly, for the pelvis/lower extremity, external signs of injury to the extremities (OR 1.07; 95% CI 1.04 to 1.10; p<0.001), and positive pelvic x-ray (OR 1.36; 95% CI 1.33 to 1.40; p<0.001) had increased odds of significant injury.

To assess older adult patients who underwent pan-scan who may have had a missed injury without receiving a pan-scan, we calculated the proportion of patients without external signs of injury or positive findings on resuscitation area imaging who had acute traumatic injury on CT, AIS score of 1–2, or AIS score ≥3 that may have been missed without a pan-scan (table 3). We found 7 (7%) patients without resuscitation area findings had acute traumatic injury on head CT, of which 4 (4%) had an AIS score of 1–2 and 3 (3%) had an AIS score ≥3. For the chest, 11 (11%) patients had acute traumatic injury on CT, 3 (3%) had an AIS score of 1–2, and 0 had an AIS score ≥3. For the spine, 5 (5%) patients had acute traumatic injury on CT with 5 (5%) patients having an AIS score of 1–2 and 0 patients having an AIS score ≥3. For the abdomen and pelvis, 2 (2%) patients had acute traumatic injury on CT with 1 (1%) having an AIS score of 1–2, and 0 patients having an AIS score ≥3.

Among 598 patients who experienced ground level fall, 138 (23%) presented with GCS<15 (table 4). A higher proportion of patients with GCS<15 underwent pan-scan (23% vs 16%; SMD=0.17) but this difference did not meet significance. A larger proportion of patients with GCS<15 had a history of

Table 3 Injuries identified on CT imaging in the absence of external signs of injury or findings on resuscitation area imaging among older adult patients who underwent pan-scan

Body region	No resuscitation area findings	Acute traumatic injury on CT	AIS score 1–2	AIS score ≥3
Head	57 (54.8)	7 (6.7)	4 (3.8)	3 (2.9)
Neck	94 (90.4)	8 (7.7)	0	0
Chest	30 (28.8)	7 (6.7)	3 (2.9)	0
Spine	76 (73.1)	5 (4.8)	5 (4.8)	0
Abdomen and pelvis	41 (39.4)	2 (1.9)	1 (1.0)	0

Percentages are computed relative to the total number of patients who underwent pan-scan (n=104).
Resuscitation area findings include external signs of injury, chest and pelvic radiographs, and ultrasound.
AIS, Abbreviated Injury Scale.

Table 4 Demographics, injury patterns, and outcomes for older adults who experienced ground level fall stratified by GCS 15 versus GCS<15

	GCS 15 (n=460)	GCS<15 (n=138)	SMD
Demographics			
Age, years, mean (SD)	82.6 (8.5)	84.5 (8.2)	**0.24**
Male, No. (%)	168 (36.5)	60 (43.5)	0.14
English-speaking, No. (%)	398 (86.5)	120 (87.0)	0.01
Unknown	0	0	
History of dementia, No. (%)	21 (4.6)	44 (31.9)	**0.88**
Unknown	5 (1.1)	10 (7.2)	
Blood alcohol>0.08 g/dL, No. (%)	7 (1.5)	8 (5.8)	**0.23**
Antiplatelet use, No. (%)	121 (26.3)	35 (25.4)	**0.28**
Unknown	13 (2.8)	13 (9.4)	
Anticoagulant use, No. (%)	110 (23.9)	28 (20.3)	**0.28**
Unknown	13 (2.8)	13 (9.4)	
CT imaging			
Pan-scan	73 (15.9)	31 (22.5)	0.17
Injury patterns			
Witnessed, No. (%)	74 (16.1)	36 (26.1)	**0.47**
Unknown	212 (46.1)	34 (24.6)	
Loss of consciousness, No. (%)	52 (11.3)	32 (23.2)	**0.82**
Unknown	54 (11.7)	51 (37.0)	
External signs of injury, No. (%)			
Head	185 (40.2)	88 (63.8)	**0.49**
Neck	45 (9.8)	11 (8.0)	0.06
Chest	128 (27.8)	38 (27.5)	0.01
Abdomen and pelvis	48 (10.4)	21 (15.2)	0.14
Back and flank	77 (16.7)	16 (11.6)	0.15
Extremity	231 (50.2)	56 (40.6)	0.19
Minor injuries (AIS score 1–2)			
Head	91 (19.8)	40 (29.0)	**0.22**
Face	97 (21.1)	46 (33.3)	**0.28**
Neck	1 (0.2)	0 (0.0)	0.07
Chest	41 (8.9)	9 (6.5)	0.09
Abdomen	8 (1.7)	6 (4.3)	0.15
Spine	46 (10.0)	9 (6.5)	0.13
Upper extremity	128 (27.8)	25 (18.1)	**0.23**
Lower extremity (including pelvis)	100 (21.7)	17 (12.3)	**0.25**
Major injuries (AIS score ≥3)			
Head	51 (11.1)	40 (29.0)	**0.46**
Face	0	0	<0.001
Neck	0	0	<0.001
Chest	98 (21.3)	20 (14.5)	0.18
Abdomen	2 (0.4)	0 (0.0)	0.09
Spine	16 (3.5)	4 (2.9)	0.03
Upper extremity	3 (0.7)	0 (0.0)	0.12
Lower extremity (including pelvis)	41 (8.9)	9 (6.5)	0.09
Outcomes			
Hospital LOS, days, mean (SD)	3.5 (3.7)	3.8 (3.3)	0.07
Procedural intervention, No. (%)	102 (22.2)	15 (10.9)	**0.31**
Head	14 (3.0)	3 (2.2)	0.06
Neck (including cervical spine)	8 (1.7)	1 (0.7)	0.09
Chest	2 (0.4)	0 (0.0)	0.09
Spine (thoracic, lumbar, sacral)	5 (1.1)	1 (0.7)	0.04
Abdomen	0	0	
Pelvis	1 (0.2)	0 (0.0)	0.07
Extremity	72 (15.7)	10 (7.2)	**0.27**
Mortality, No. (%)	3 (0.7)	5 (3.6)	**0.21**
Follow-up CT imaging ordered, No. (%)	22 (4.8)	8 (5.8)	0.05
Acute injury on follow-up CT imaging, No. (%)	6 (1.3)	0	**0.87**

Bold face indicates significant effect size defined as SMD ≥0.2.
AIS, Abbreviated Injury Scale; GCS, Glasgow Coma Scale; Hospital LOS, hospital length of stay; SMD, standardized mean difference.

dementia (32% vs 5%; SMD=0.88) and a higher proportion had blood alcohol >0.08 g/dL (6% vs 2%; SMD=0.23). A higher proportion of patients with GCS<15 had loss of consciousness (23% vs 11%; SMD=0.82), external signs of injury to the head (64% vs 40%; SMD=0.49), and a higher proportion had an AIS score of 1–2 to the head (29% vs 20%; SMD=0.22) and face (33% vs 21%; SMD=0.28) but a lower proportion had injury to the upper extremity (18% vs 28%; SMD=0.23) and lower extremity (12% vs 22%; SMD=0.25). A higher proportion of patients with GCS<15 had an AIS score ≥3 to the head (29% vs 11%; SMD=0.46). A higher proportion of patients with GCS 15 underwent procedural intervention (11% vs 22%; SMD=0.31) including a greater proportion undergoing procedural intervention to the extremities (7% vs 16%; SMD=0.27). Mortality was higher among patients with GCS<15 (4% vs 1%; SMD=0.21).

DISCUSSION

This single center, retrospective study of older adult patients who experienced ground level falls investigated whether routine pan-scanning identifies a larger proportion of patients with significant injury or injury requiring procedural intervention, when compared with targeted imaging. We found a lower proportion of patients who underwent pan-scan received procedural intervention. Furthermore, we found that very few patients (n=2) underwent procedural intervention for the chest—both with pneumothorax on chest X-ray—and no patients underwent procedural intervention for the abdomen. On multivariable regression, resuscitation area findings to the chest were associated with significant injury. Our data show that patients who underwent pan-scan did not have a higher proportion of injuries resulting in procedural intervention, that there was a significant association between resuscitation area findings and chest injury, and there were very few significant abdominal injuries (AIS score ≥3, none of which required procedural intervention). Further, we found pan-scan identified no significant injuries with an AIS score ≥3 to the chest and abdomen/pelvis among patients without external signs of injury or findings on resuscitation area imaging to these body regions (ie, missed injuries without CT imaging). These findings suggest that resuscitation area findings may guide a targeted imaging approach to the chest and abdomen/pelvis compared with pan-scanning patients with injuries to these body regions.

Previous studies comparing pan-scanning versus targeted CT imaging among patients with blunt traumatic injuries have found inconsistent results in its association with mortality and hospital length of stay, with some finding no difference[8 16] and others finding increased mortality and length of stay associated with targeted imaging.[17 18] A past study of older adult patients after ground level fall found pan-scans were associated with increased length of stay but no difference in mortality.[9] We did not find a

difference in mortality or hospital length of stay between patients who underwent pan-scan versus targeted imaging.

Injured patients without external signs of injury or findings on resuscitation area imaging represent those at risk of having missed injury who would likely benefit from CT imaging. Our study supports past evidence that resuscitation area findings to the head and neck are unreliable because a significant proportion of patients without resuscitation area findings underwent procedural intervention or had significant injury which may require non-procedural management such as cervical collar stabilization.[5 19] Accordingly, our data suggests that older adult patients who fall from ground level would benefit from a routine CT scan of the head and neck regardless of resuscitation area findings especially considering the significant and potentially catastrophic consequences of a missed injury to these regions.

In examining patients who underwent pan-scan but did not have external signs of injury or findings on chest or pelvic X-ray, we found only three patients with an AIS score of 1–2 to the chest and one patient with an AIS score of 1–2 to the abdomen and pelvis whereas no patients had significant injury of AIS score ≥3 to either the chest or abdomen/pelvis. Two of the three patients with an AIS score of 1–2 to the chest had single rib fractures and the third had a subcutaneous hematoma whereas the one patient with an AIS score of 1–2 to the abdomen and pelvis had evidence of laceration to the liver, which are all injuries that may have been missed without pan-scanning. Among patients in our cohort who underwent targeted imaging, two patients had acute injuries identified on follow-up CT imaging including one patient with non-segmental rib fractures and the second patient having a vertebral compression fracture both of whom exhibited physical examination findings on tertiary examination that prompted the CTs. Although not diagnosed by index CT imaging, these injuries were found on tertiary examination where follow-up imaging was warranted. This suggests that routine pan-scanning after a ground level fall in elderly patients may not be warranted, particularly if they are re-evaluated with a tertiary examination as an opportunity to diagnose minor missed injuries. Lastly, we found only two patients in our cohort had significant abdominal injury (AIS score 3) consistent with past studies finding abdominal injuries are uncommon after ground level fall.[3 6 20–23] Both of these patients had external signs of injury which would have prompted a CT of the abdomen and pelvis, but neither required any procedural intervention. Although more patients are undergoing pan-scanning, we lack consistent results indicating survival benefit, decreased incidence of missed injuries, or the reduction of hospital resources used to care for patients.[24]

Our study has several limitations, particularly due to its retrospective nature. The clinical decision to perform a procedural intervention may be different from the necessity of performing the procedural intervention. For example, in our study, two patients underwent tube thoracostomy for pneumothorax, but the procedure may not have altered their clinical course depending on the size of the pneumothorax. Similarly, as there are no set protocols for imaging patients who underwent a ground level fall at our institution, whether or not patients had a pan-scan was also a decision made by the provider's clinical judgment, therefore we cannot analyze which patients actually needed a pan-scan. Although patients who did not undergo pan-scan may theoretically have undiagnosed injuries, in our dataset, no patients undergoing targeted imaging were found to have delayed diagnoses of injuries that altered their clinical course and required a procedural intervention. Although it is possible a CT scan identified injury requiring procedural intervention otherwise missed on X-ray or physical examination, it may also be possible a CT scan provides clinical information that reassures the surgeon that a patient does not need procedural intervention. The granularity of our data was limited by not including incidental CT findings which have been suggested in prior studies to prolong hospital length of stay even when they do not necessitate a change in management and are most common among older adults.[25–27] Further, the granularity of our data was limited to only procedural interventions, and we acknowledge the importance of non-operative management such as physical therapy, pain management, and thoracic-lumbar-sacral orthosis, for example. Some patients with minor injuries identified on CT that would have otherwise been missed may have benefitted from non-operative management. We also remain limited by our retrospective study design, which prevents causal inference, the quality of documentation, and our relatively small sample size. In particular, due to the relatively small number of patients in our study with altered mental status from causes such as intoxication or other pathology, our recommendations are not well supported for this population, which requires further study. Lastly, this study was conducted at a well-resourced urban level I trauma center and therefore the findings may be limited in generalizability to other settings.

In conclusion, the incidence of ground level falls among older adults continues to increase and routine pan-scanning has become commonplace despite the lack of strong evidence supporting its benefit. In this retrospective study, we found resuscitation area findings to the head and neck to be unreliable indicators of significant injury, but resuscitation area findings were reliable indicators of significant injury for the chest and abdomen/pelvis. Overall, our results suggest obtaining a head and neck CT would be reasonable regardless of resuscitation area findings, but targeted imaging based on resuscitation area findings should be considered for other body regions. As our findings were based on data from a single institution, level 1 trauma center with the capabilities of close clinical monitoring and protocols of mandated tertiary examinations, the generalizability of our recommendations may be limited to such institutions with similar capacity. Further prospective studies are warranted to investigate whether individual risk and institutional burden associated with pan-scanning is outweighed by its benefit.

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