ORIGINAL ARTICLE

Ground level falls: computed tomography findings and clinical outcomes by age groups

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ABSTRACT

BACKGROUND: This study aimed to determine injury patterns in ground level falls (GLFs) and investigate the effect of age on the severity of injury.

METHODS: We retrospectively identified 4,712 patients who presented to a Level 1 trauma center due to GLFs and analyzed the data of 1,214 patients who underwent computed tomography (CT). Demographics, torso examination findings, and injuries detected on CT were recorded. To investigate the effect of age on injury severity, the patients were grouped as those aged <65 and ≥65 years.

RESULTS: The mean age was 57 years, and 55.20% of the patients were female. The mortality rate was 0.50%. Injury was detected in 489 (40.30%) patients on CT. Fractures were the most common injury type. Traumatic intracranial hemorrhage was detected in 32 (2.60%) patients. Only three (0.20%) of the 63 patients with rib fractures had concomitant lung injury. The negative predictive value of the physical examination (PE) was 95.80% for chest injury. Intra-abdominal injury was not detected in any of the 116 patients who underwent abdominal CT. Hospitalization was also higher in the ≥65-year group (p<0.001). All mortalities (n=6) were seen in patients aged ≥65 years.

CONCLUSION: Our results indicate that GLFs cause more injuries in the elderly, resulting in more hospitalizations and mortality. Normal PE findings may reduce the need for whole-body CT in GLF patients who are conscious, cooperative, and oriented.

Keywords: Computed tomography; ground-level fall; injury; trauma.

INTRODUCTION

Falls are a major cause of injury in all age groups. According to the World Health Organization, falls are the second greatest reason for accidental or unintentional injury in the world, after motor vehicle accidents.[1,2] A ground level fall (GLF) is a low-energy form of trauma that can occur in all age groups, but it is the most common mechanism of trauma in geriatric patients. GLF can cause serious injuries including fractures and intracranial and spinal cord injuries in the elderly compared with the younger patients.[3-5] Older patients sustaining injuries in a GLF have higher mortality risk compared to younger patients.[6-8] In a study about fall-related injuries, head and neck and pelvic/extremity injuries were more frequent and severe in GLF patients older than 65 years, with a mortality 10 times higher than in patients younger than 65 years.[6] Visceral organ injuries due to GLF are less common in all age groups.[3-5]

Computed tomography (CT) is an important diagnostic method to be used in the triage and treatment of trauma patients.[1,3-5,9] CT protocols in trauma differ between healthcare centers. While some prefer a whole-body CT (WBCT) scan for each trauma patient, others focus on certain body parts according to the type of trauma, the patient's clinical condition, and physical examination (PE) findings.[1,3-5,9] Some meta-analyses comparing WBCT and selective CT suggest that the former is associated with better outcomes, such as lower mortality rates.[10,11] However, it is stated that especially

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in low-energy traumas such as GLF, selective CT scanning according to PE findings would be sufficient in the diagnosis of injuries, and this would protect the patient from unnecessary radiation exposure.[1,12,13] It should be kept in mind that the intravenous contrast agent to be used especially for abdominal CT may deteriorate the already decreased renal functions in elderly patients, as well as incurring additional costs.[12-14] Therefore, CT should be used considering the benefits and risks for each patient.[12]

Today, lifestyle improvements and advances in medical care have led to a longer lifespan and an increase in the elderly population, contributing to increased trauma rates among the geriatric patients.[5] It is predicted that the numbers of falls will increase in magnitude as the numbers of older adults increase in many nations throughout the world.[4,5,14,15] However, there are only limited studies examining injury patterns and imaging findings due to GLF.[13,16] Therefore, our aim in this study was to investigate the effect of age on the type and severity of injury in GLF. We also investigated the diagnostic reliability of the selective CT scan instead of WBCT according to the clinical condition of the patient.

MATERIALS AND METHODS

After receiving approval from the institutional review board (E1-21-1853), we retrospectively identified 4,712 patients who had been admitted to a high-volume Level I trauma center due to GLF between January 2020 and September 2020 and included 1,214 consecutive patients who underwent regional CT or WBCT. Patients younger than 18 years of age and those with a Glasgow coma scale (GCS) score of <15 were not included in the study (Fig. 1). Only the conscious, cooperative, and fully oriented patients with a GCS of 15 were included in the study to ensure the reliability of PE findings. Data extracted included basic patient demographics and outcomes, GCS scores, injury times, torso examination findings, and outcomes (inpatient mortality or discharge). The reports of focused assessment sonography for trauma (FAST) performed in radiology were collected. Hospital data were derived from picture archiving and communication system for CT scans, and other data were retrieved from the medical records. The CT scans of the patients were retrospectively evaluated by two radiologists experienced in emergency radiology. Anatomical regions examined by CT and injury patterns were classified.

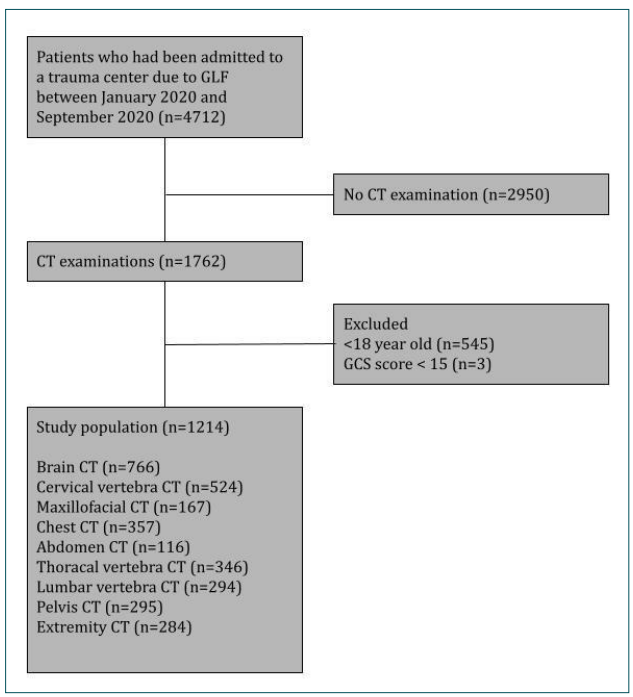

Figure 1. Flow diagram for the study population selection.

The standard WBCT protocol in our hospital includes a non-contrast scan of the brain, neck, a contrast-enhanced scan of the chest, abdomen, and pelvis. The coronal and sagittal images of cervical, thoracic, and lumbar spines are also reformatted. All CT scans were performed using a 128-slice multidetector scanner (GE, Revolution EVO, USA).

Statistical analysis was performed using SPSS version 23.0 (SPSS Inc., Chicago, IL, USA). The normality analysis of continuous variables was performed with the Kolmogorov–Smirnov test. Descriptive statistics, namely, numbers and percentages were given for categorical variables and median (minimum-maximum) values for numerical variables. The Mann–Whitney-U test was used for the analysis of differences in numerical variables between two independent groups. The comparison of the ratios in independent groups was undertaken with the chi-square analysis. The statistical alpha significance level was accepted as $p<0.05$.

RESULTS

Of the 4,712 patients who were admitted to the emergency room due to GLF, 1,214 who underwent CT and met the

Table 1. Characteristics of the study sample

	n (%)
Age	
<65 years	685 (56.40)
≥65 years	529 (43.60)
Gender	
Female	670 (55.20)
Male	544 (44.80)
Physical examination (torso)	
Normal	1,093 (89)
Abnormal	121 (11)
Outpatient	986 (81.20)
Hospitalization	228 (18.80)
Mortality	6 (0.50)

Table 2. Relationship between the number of CT scans and injuries

	n (%)	
WBCT	94 (7.7)	
	Abnormal findings	**Normal findings**
CT abnormality	489 (40.30)	725 (59.70)
Brain	46 (6)	720 (94)
Cervical	1 (0.20)	523 (99.80)
Maxillofacial	68 (40.70)	99 (59.30)
Chest	67 (18.80)	290 (81.20)
Abdomen	-	116 (100)
Thoracic vertebra	19 (5.50)	327 (94.50)
Lumbar vertebra	47 (16)	247 (84)
Pelvis	104 (35.30)	191 (64.70)
Extremity	184 (64.80)	100 (35.20)

CT: Computed tomography.

study criteria were included in the sample. The mean age of patients was 57 years (range 19–99 years), and 55.20% were female. While 986 (81.20%) patients were treated as outpatients, 228 (18.80%) were hospitalized. Six (0.50%) cases of GLF resulted in death: four died after hip operations, one died following intracranial hemorrhage, and one patient died after developing the COVID-19 infection in the postoperative period (Table 1).

Injury was detected in 489 (40.30%) patients on CT (Table 2). The most common abnormality was fractures, which were mostly seen in the extremities (21.40%). Intertrochanteric (6%) and femoral neck (4.70%) fractures were the most common extremity fractures (Table 3). Traumatic intracranial hemorrhage was detected in 32 (2.60%) patients, and only one patient from this group died. Lumbar compression fractures (2.40%) were the most common vertebral fracture type. Cervical vertebral fracture was detected in only one patient, and it was located in the spinous process of C3. Vertebral corpus fractures were in the form of compression (Table 3). While rib fractures were detected in 63 patients (5.20%), lung injury was accompanied in three patients (0.20%). Chest injury was detected in 56 of the 93 patients who had abnormal PE findings. Chest PE had a positive predictive value of 60.20% in detecting injury. Of the 264 patients with normal chest PE findings, 11 had an injury, resulting in a negative predictive value (NPV) of 95.80% (sensitivity for chest injury 83.50% and specificity 87.20%) in the detection of injuries. Abdominal PE findings were abnormal in 28 of the 116 patients who underwent abdominal CT, whereas PE was normal in 88 patients. There was no evidence of intra-abdominal injury in any of the abdominal CT investigations. Normal PE findings had an NPV of 100% for abdominal injury (specificity for abdominal injury 75.80%) (Table 4). None of the 69 (5.70%) patients who underwent FAST in the emergency radiology unit had positive findings.

WBCT was preferred in 94 (7.70%) patients whose ages were statistically higher (p=0.009). The mean age of the patients with injuries detected on CT was also higher (p<0.001). The mean age of the patients with pelvic and extremity fractures was statistically higher than those without fractures

Table 3. Injury details by anatomical region

Brain CT	**n (%)**	**Extremity CT**	**n (%)**
Intracranial hemorrhage	32 (2.60)	Intertrochanteric fracture	73 (6)
Cranium fracture	10 (0.80)	Femoral head fracture	57 (4.70)
Nasal bone fracture	42 (3.50)	Femoral shaft/distal end fracture	11 (0.90)
Maxillofacial fracture	17 (1.40)	Patella fracture	9 (0.70)
Chest CT		Tibia fracture	9 (0.70)
Rib fracture	63 (5.20)	Malleolus fracture	18 (1.50)
Lung injury	3 (0.20)	Tarsal bone fracture	1 (0.10)
Sternum fracture	1 (0.10)	Prosthesis dislocation	4 (0.30)
Clavicle fracture	1 (0.10)	Humeral head/neck fracture	31 (2.60)
Vertebra-Pelvis CT		Shoulder dislocation	5 (0.40)
Cervical vertebra fracture	1 (0.10)	Elbow fracture/dislocation	15 (1.20)
Thoracic vertebra comp fracture	22 (1.80)	Radius distal end fracture	31 (2.60)
Lumbar vertebra comp fracture	29 (2.40)	Carpal bone fracture	6 (0.50)
Pelvis fracture	24 (2)		
Posterior vertebral column fracture	21 (1.70)		

CT: Computed tomography.

Table 4. Relationship between torso physical examination findings and injuries detected on CT

Physical examination	Injury on CT		
	Total (n)	Normal (n)	Abnormal (n)
Chest			
Negative	264	253	11
Positive	93	37	56
Abdomen			
Negative	88	88	0
Positive	28	28	0

CT: Computed tomography.

(p<0.001). When the injury subgroups were evaluated, intracranial hemorrhages (p=0.002), intertrochanteric fractures (p<0.001), femoral neck fractures (p<0.001), lumbar compression fractures (p=0.002), and pelvic fractures (p<0.001) were more common in the elderly patients (Table 5). We divided the patients into two groups as <65 and ≥65 years. Injuries were statistically significantly higher in patients aged ≥65 years (p<0.001). Intracranial hemorrhages (p<0.001), intertrochanteric fractures (p<0.001), femoral neck fractures (p<0.001), lumbar compression fractures (p=0.005), and pelvic fractures (p<0.001) were statistically significantly higher in the ≥65-year group. Hospitalizations were also more common in the ≥65 years group (p<0.001). All mortalities (n=6) were seen in the patients aged ≥65 years (Table 6).

DISCUSSION

GLF is the most common cause of traumatic intracranial hemorrhage worldwide, accounting for almost 80% of cases. The available literature indicates that the incidence of GLF-related intracranial hemorrhage in the elderly is approximately 5%.[17] The incidence of traumatic intracranial hemorrhage was 2.60% in the current study which consists of patients >18 years old. In a study of 5088 patients older than 18 years of age, the incidence of intracranial hemorrhage was reported as 1.3%.[18] Due to low intracranial hemorrhage risk, brain CT indication is discussed in GLFs without head trauma. These patients are generally elderly, and a clear history of head trauma cannot always be obtained. It is emphasized that there are cases of intracranial hemorrhage without any direct or facial impact.[17] Benayoun et al. investigated cervical fractures in GLF patients and detected fractures in only 7/760 (0.92%±0.68%) patients. They concluded that cervical spine CT is overused in GLFs.[19] In the current study, cervical CT was performed in 524 patients, and fracture was detected in only 1 (0.10%) patient in accordance with the literature.

Table 5. Statistically significant injuries according to age

	Age, years, mean±SD	p
Hospitalization		
+	71.10±17.50	<0.001
–	54.50±22	
Mortality		
+	80.20±7.90	0.010
–	57.50±22.20	
Intracranial hemorrhage		
+	69.70±15.30	0.002
–	57.30±22.20	
Intertrochanteric fracture		
+	80.90±10.90	<0.001
–	56.10±21.90	
Femoral head fracture		
+	76.30±11.60	<0.001
–	56.70±22.20	
Lumbar vertebra compression fracture		
+	70.20±16.50	0.002
–	57.30±22.20	
Pelvic fracture		
+	79	<0.001
–	57.20±22.10	

Table 6. Distribution of injuries by age groups (<65 and ≥65 years)

	Age group, n (%)		p
	<65 years	≥65 years	
Gender			
Female	321 (46.90)	349 (66)	<0.001
Male	364 (53.10)	180 (34)	
Abnormality on CT			
+	210 (30.70)	279 (52.70)	<0.001
–	475 (69.30)	250 (47.30)	
Hospitalization			
+	66 (9.60)	162 (30.60)	<0.001
–	619 (90.40)	367 (69.40)	
Mortality			
+	0 (0)	6 (1.10)	0.005
–	685 (100)	523 (98.90)	
Intracranial hemorrhage			
+	8 (1.20)	24 (4.50)	<0.001
–	677 (98.80)	505 (95.50)	
Intertrochanteric fracture			
+	6 (0.90)	67 (12.70)	<0.001
–	679 (99.10)	462 (87.30)	
Femoral neck fracture			
+	9 (1.30)	48 (9.10)	<0.001
–	676 (98.70)	481 (90.90)	
Lumbar vertebra compression fracture			
+	9 (1.30)	20 (3.80)	0.005
–	676 (98.70)	509 (96.20)	
Pelvic fracture			
+	3 (0.40)	21 (4)	<0.001
–	682 (99.60)	508 (96)	

CT: Computed tomography.

In the current study, fractures were determined to be the most common type of injury among the patients presenting to the hospital after GLFs. Femoral neck and intertrochanteric fractures were detected in 10% of all patients. Kaiser et al. examined 596 patients with GLF and reported the most common injury type as fractures, most of which were located in the lower extremity, followed by the upper extremity.[2]

GLF is a significant cause of mortality and morbidity for the geriatric patients.[18] A retrospective review of trauma registry data prospectively collected on 26,237 patients with blunt trauma showed that elderly patients aged ≥65 years had a two to threefold increase in the mortality rate compared to younger patients.[20] Possible causes of injury susceptibility in the elderly patients are decreased muscle tone, decreased bone density, and physical inactivity that deteriorate with age.[1,14] Spaniolas et al. reported that, in the elderly (>70 years), GLF was statistically significantly more mortal. Long bone fractures, pelvic fractures, and intracranial injuries were significantly higher in the elderly group.[21] In our study, similar to the literature, long bone fractures, especially intertrochanteric and neck fractures in the proximal femur, were found more frequently, and the rates of these fractures and other injuries were statistically significantly higher among the patients over 65 years. However, it is known that almost three-quarters of patients with GLF are not severely injured, and the over-triage of these patients can lead to potentially unbearable strain on emergency physicians.[21] We detected injuries on CT in 489 (40.30%) patients, but the number of serious injuries was very low. A total of six patients, all aged >65 years, died but only one patient died secondary to trau-

matic intracranial hemorrhage, whereas the remaining five patients died in the postoperative period of hip surgery.

Many trauma protocols include the imaging of the thorax and abdomen in all trauma patients to avoid overlooking significant injuries.[13,22] However, intra-abdominal injuries are rare in GLF.[13,15,22] Gartin et al. investigated intra-abdominal injuries caused by GLF in patients older than 65 years with pelvic, thoracolumbar, and lower rib fractures. Although 22 (6.80%) of 324 patients had abnormal PE findings, intra-abdominal injury was detected in only three (0.90%) of the 91 (28.10%) patients that underwent abdominal CT. None of these patients required surgical intervention.[15] There are also other GLF studies in the literature reporting a low incidence of abdominal injury; e.g., 0.80% and 0.60%.[2,18] A comprehensive PE in the trauma bay has a 100% NPV in assessing significant thoracic or intra-abdominal injury. In low-energy trauma, WBCT is not necessary in the absence of abnormal PE findings.[13] In our study, lung injury was detected in only three patients, of whom none required surgical intervention. The NPV of PE in chest injury was 95.80%. Intra-abdominal injury was not detected in any of the 116 patients who underwent abdominal CT. Although this was similar to the literature, our result was even more remarkable. The NPV of PE in intra-abdominal injury was 100%. The current study showed that, if the torso PE findings are normal in patients with GLFs, there is no need for chest or abdomen CT.

The retrospective nature of the study is a notable limitation. Another limitation is that the study was performed at a single institution, and therefore the results may not be universally applicable to other institutions. We were also unable to assess the impact of pre-existing comorbidities or functional performance prior to injury.

Conclusion

Falls are a growing health problem in the elderly population due to higher injury and mortality rates; thus, more CT scans may be needed in this patient group. However, in conscious, cooperative, and fully oriented elderly patients, PE may help to reduce the number of WBCT imaging and the risks associated with radiation exposure.

Ethics Committee Approval: This study was approved by the Ankara City Hospital Clinical Research Ethics Committee (Date: 09.06.2021, Decision No: E1-21-1853

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Authorship Contributions: Concept: S.P., E.C., M.S.B., S.G.; Design: S.P., E.C., M.S.B., S.G.; Supervision: S.P., E.C., M.S.B., S.G.; Materials: S.P., E.C., M.S.B.; Data: S.P., E.C., M.S.B.; Analysis: S.P., E.C., M.S.B.; Literature search: S.P., M.S.B.; Writing: S.P.; Critical revision: S.P., E.C., M.S.B., S.G.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Zemin seviyesinden düşmeler: Yaş gruplarına göre bilgisayarlı tomografi bulguları ve klinik sonuçlar

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AMAÇ: Bu çalışma, zemin seviyesinden düşmelerde yaralanma paternlerini belirlemeyi ve yaşın yaralanma şiddeti üzerindeki etkisini araştırmayı amaçlamıştır.
GEREÇ VE YÖNTEM: Zemin seviyesinden düşmeler nedeniyle seviye 1 travma merkezine başvuran 4712 hastayı retrospektif olarak belirledik ve bilgisayarlı tomografi (BT) çekilen 1214 hastanın verilerini analiz ettik. Demografi, gövde muayene bulguları, BT'de tespit edilen yaralanmalar kaydedildi. Yaşın yaralanma şiddeti üzerindeki etkisini araştırmak için hastalar <65 ve ≥65 yaş olarak gruplandırıldı.
BULGULAR: Ortalama yaş 57 idi ve hastaların %55.20'si kadındı. Mortalite oranı %0.50 idi. BT'de 489 (%40.30) hastada yaralanma tespit edildi. Kırıklar en sık görülen yaralanma tipiydi. 32 (%2.60) hastada travmatik kafa içi kanama tespit edildi. Kaburga kırığı olan 63 hastanın sadece üçünde (%0.20) eşlik eden akciğer hasarı vardı. Fizik muayenenin negatif prediktif değeri göğüs yaralanması için %95.80 idi. Abdominal BT çekilen 116 hastanın hiçbirinde batın içi yaralanma tespit edilmedi. ≥65 yaş grubunda hastaneye yatış da daha yüksekti (p<0.001). Tüm ölümler (n=6) ≥65 yaş hastalarda görüldü.
TARTIŞMA: Sonuçlarımız, zemin seviyesinden düşmelerin yaşlılarda daha fazla yaralanmaya neden olarak daha fazla hastaneye yatış ve ölümle sonuçlandığını göstermektedir. Normal fizik muayene bulguları, zemin seviyesinden düşen, bilinci açık, koopere ve oryante hastalarda tüm vücut BT'ye gerekliliği azaltabilir.
Anahtar sözcükler: Bilgisayarlı tomografi; travma; yaralanma; zemin seviyesinden düşme.

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