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Falls from ladders: age matters more than height

Jorge Con, MD[a,*], **Randall S. Friese, MD**[b], **Dustin M. Long, PhD**[c], **Bardiya Zangbar, MD**[b], **Terence O'Keeffe, MD**[b], **Bellal Joseph, MD**[b], **Peter Rhee, MD**[b], and **Andrew L. Tang, MD**[b]

[a]Department of Surgery, West Virginia University, Morgantown, West Virginia

[b]Department of Surgery, University of Arizona, Tucson, Arizona

[c]Department of Biostatistics, West Virginia University, Morgantown, West Virginia

Abstract

Background—Falls from ladders account for a significant number of hospital visits. However, the epidemiology, injury pattern, and how age affects such falls are poorly described in the literature.

Materials and methods—Patients ≥18 y who suffered falls from ladders over a 5½-y period were identified in our trauma registry. Dividing patients into three age groups (18–45, 46–65, and >66 y), we compared demographic characteristics, clinical data, and outcomes including injury pattern and mortality. The odds ratios (ORs) were calculated with the group 18–45 y as reference; group means were compared with one-way analysis of variance.

Results—Of 27,155 trauma patients, 340 (1.3%) had suffered falls from ladders. The average age was 55 y, with a male predominance of 89.3%. Average fall height was 9.8 ft, and mean Injury Severity Score was 10.6. Increasing age was associated with a decrease in the mean fall height ($P < 0.001$), an increase in the mean Injury Severity Score ($P < 0.05$), and higher likelihood of admission (>66 y: OR, 5.3; confidence interval [CI], 2.5–11.5). In univariate analysis, patients in the >66-y age group were more likely to sustain traumatic brain injuries (OR, 3.4; CI, 1.5–7.8) and truncal injuries (OR, 3.6; CI, 1.9–7.0) and less likely to sustain hand and/or forearm fractures (OR, 0.3; CI, 0.1–0.9).

Conclusions—Older people are particularly vulnerable after falling from ladders. Although they fell from lower heights, the elderly sustained different and more severe injury patterns. Ladder safety education should be particularly tailored at the elderly.

Keywords

Fall from ladder; Head injuries; Truncal injuries; Extremity fractures; Geriatric trauma

*Corresponding author. Department of Surgery, Health Sciences Center, West Virginia University, P.O. Box 9238, Morgantown, West Virginia 26506-9238. Tel.: +1 304 293 0583; fax +1 304 293 8881., jocon@hsc.wvu.edu (J. Con).

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1. Introduction

Ladders are ubiquitous tools, both at home and in the work-place. Available studies that address falls from ladders indicate a fatality rate of 0%–2% [1,2]. The low fatality rate contributes to the common notion that falls from ladders are not dangerous. However, the health care costs and opportunity costs from such falls are significant, with one study finding an average hospital stay of 1 wk followed by 6 wk of disability [1].

The aging population is particularly vulnerable to sustaining injury from falls of any kind. Falls represent the most common cause of unintentional injury and death by the sixth decade of life, accounting for >40% of all trauma-related deaths in this age group [3–5]. Injuries from falls of any kind are more frequent in this age group; and increasing age is associated with increased injury severity, morbidity, and mortality [6,7]. In a retrospective study that examined ladder and structural falls, Diggs found that in those patients >75 y, mortality could be as high as 3.3% [8].

The aim of our study was to determine the epidemiology and injury pattern of falls from ladders. Because individuals ≥66 y may constitute a special population at risk for suffering significant injuries from such falls, we emphasized the impact of increasing age.

2. Methods

The University of Arizona Medical Center Trauma Registry was queried to identify all patients >18 y who sustained falls from ladders (*International Classification of Diseases, Ninth Revision* E881.0) between January 1, 2006 and June 30, 2011. The following data were extracted and analyzed: age, sex, location and height of fall, Injury Severity Score (ISS), Glasgow Coma Scale (GCS), systolic blood pressure on presentation, and injuries sustained. Outcomes included mortality, hospital, and intensive-care unit (ICU) lengths of stay.

Patients were divided into three age groups: 18–45, 46–65, and ≥66 y. Mean height of fall and mean ISS were compared with one-way analysis of variance with Tukey–Kramer post hoc analysis. Intergroup analysis was performed using age 18–45 y as the reference group to identify the odds ratio (OR) for the likelihood of hospital admission, ICU admission, and sustaining severe and multiple injuries. Sustaining multiple injuries was defined as having Abbreviated ISS ≥2 in more than one region, and sustaining severe injuries as having an ISS >15.

Injury locations were classified into head, spine, thoracic, abdominal, pelvic, upper extremities, and lower extremities. Head injuries included concussions, skull fractures, and intracranial hemorrhage of any kind. Spine fractures occupied a category by itself. Thoracic injuries included rib fractures, pulmonary contusions, hemothoraces, and pneumothoraces, but excluded thoracic spine fractures. In a similar manner, abdominal injuries included solid and hollow viscus injuries, but excluded thoracolumbar spine fractures and pelvic fractures. Extremity fractures were further divided into upper and lower. We defined truncal injuries to include everything except for head or extremity injuries, namely an injury to the spine, thorax, abdomen, and/or pelvis. Groups were compared to identify differences in the anatomic distribution of their injuries. Odds ratios were calculated for each age group using the 18–45 y age group as reference. A multivariate model was created using admission as an endpoint and correcting for age groups, ISS ≥15, fall height, gender, GCS ≤8, and systolic blood pressure on arrival.

3. Results

Over the study period, there were 27,155 trauma-related emergency department evaluations, of which 340 (1.3%) had suffered falls from ladders. The population was predominantly male (89.3%) with an average age of 56 ± 15 y (range, 20–92 y). The age group distributions were 82 patients (24%) in the age group 18–45 y, 176 patients (52%) in the age group 46–65 y, and 82 patients (24%) in the age group ≥66 y. During the initial 5 y of the study, our hospital saw a significant increase in the incidence of people sustaining falls from ladders ($P < 0.03$), but there were no differences among age groups ($P < 0.1$).

Most of the falls happened at home (67% home; 9% work-place; and 24% other) from an average height of 9.8 ft (range, 0–40 ft). Although this was true across all age groups, it was more pronounced in the age group ≥66 y, where 90% of the falls occurred at home (Table 1).

The average height of the fall was 9.8 ft (Standard Deviation, 5.4; range, 0–40 ft). Group age inversely correlated with the mean fall height (12.6 ft for age group 18–45 y; 9.4 ft for age group 46–65 y, $P < 0.001$; and 7.8 ft for age group ≥66 y, $P < 0.001$). The mean ISS was 10.6 (Standard Deviation, 8.6; range, 1–45) with 21% ($n = 71$) of patients presenting with severe injuries ISS >15. Group age was correlated with increasing mean ISS: 8 for age group 18–45 y, 11 for age group 46–65 y, and 13 for age group ≥66. Moreover, older patients were more likely to have an ISS ≥15 (age ≥ 66; OR, 3.8; confidence interval [CI], 1.6–8.7) and have more than one injury (age ≥ 66; OR, 2.7; CI, 1.4–5.2). The median GCS was 15, and there were no differences among groups.

Overall mortality was 3.8% ($n = 13$). All deaths occurred in the older age groups, but the odds were not statistically significant from each other (4.6% for age group 46–65 y; 6.1% for age group 66 and older, $P = 0.60$). The average time to death was 4.8 ± 5.4 d. Most of the patients who died suffered head injuries 11 of 13 (85%) and fractures eight of 13 (62%). The median GCS in the emergency department of those who died was 8, the median ISS was 25, and the median head–Abbreviated ISS was 5. Among those who died, we did not find differences in injury severity or pattern among age groups.

The average length of stay was 6 ± 7.3 d, the average ICU stay was 4.2 ± 6.2 d, and the average ventilator days were 6 ± 6.1 d. There was a stepwise increase in the likelihood of requiring hospital admission (age, 46–65 y; OR, 2.8; 95% CI, 1.6–4.9 and age, ≥66 y; OR, 5.9; CI, 2.7–13.1) and ICU admission (age, 46–65 y; OR, 2.0; 95% CI, 1.0–4.0 and age, ≥66 y; OR, 4.2; CI, 2.0–8.7). The average hospital length of stay was 3.4 d longer for those ≥66 y ($P < 0.002$); however, we found no differences in ICU length of stay or ventilator days among groups (Table 2). The most common reason for admission was the need for an operation (47%), and most of these were for an orthopedic procedure (52%). There were no significant differences among age groups regarding the need for an operation or the type of procedure performed. Head injuries were present in 62 of 257 admissions (24%), and they occurred significantly more frequently in the older age groups: 15% of those ages 18–45 y, 23% of those ages 46–65 y, and 31% of those ages ≥66 y ($P < 0.01$).

Head injuries were present in 66 patients (19.41%; Table 3) and was significantly more common in the age group ≥66 y compared with our reference group of 18–45 y (OR, 3.4; 95% CI, 1.5–7.8; Table 4). Thoracic injuries were found in 99 patients (29.1%; Table 3), and their incidence increased by age groups (age, 46–65 y; OR, 1.9; 95% CI, 1.0–3.7 and age, ≥66 y; OR, 2.7; 95% CI, 1.3–5.6). Abdominal and pelvic injuries occurred in 25 (7%) and 34 (10%) patients, respectively, and there were no age related differences among groups. Among the 170 (50%) patients who sustained truncal injuries, it was significantly more common in age group ≥66 y (OR, 2.2; 95% CI, 1.2–4.1), and there was a trend toward significance in the age group 45–65 y (OR, 1.6; 95% CI, 0.9–2.8).

There were 88 (26%) patients with spine injury, 20 of whom had multilevel injuries. These were most frequent in the thoracic spine, followed by lumbar spine (Table 1). There were no significant differences in the incidence of spine fracture among age groups (Table 5).

Upper-extremity fractures were present in 60 (18%, Table 1) patients. The most common location was in the forearm, with 44 (13%) patients having either ulna and/or radius fractures. Forearm fractures were most common in the age group 18–45 y and significantly less common in those ≥66 y (OR, 0.4; 95% CI, 0.1–0.9; Table 6). Lower-extremity fractures occurred in 64 patients (19%) with no age-related influence on fracture location and incidence.

In our multivariate model using admission as endpoint, we corrected for age groups, ISS ≥15, fall height, gender, GCS ≤8, and systolic blood pressure on arrival. The age group variable correlated with admissions (age, 46–65 y; OR, 2.4; 95% CI, 1.3–4.5 and age, ≥66 y; OR, 4.9; 95% CI, 2.0–11.6), and the ORs obtained are similar to those from Table 3. Of the remaining variables, only having an ISS ≥15 correlated with admission, whereas fall height and the remaining variables did not.

4. Discussion

The average American life expectancy has been steadily rising. According to the World Bank, it is currently 78.6 y compared with 69.7 y in 1960 [9]. As Americans live longer, it is also accompanied by the increased need and desire to remain independent. According to Gallup Economy and Personal Finance Survey, the average American retirement age has climbed to 61 y, up from 57 y, two decades ago. The average nonretired American now plans to retire at 66 y, up from 60 y, in 1995 [10]. About 29% (11.3 million) of noninstitutionalized older persons live alone. Almost half of women ≥75 y live alone.

An aging population exerts tremendous pressure on health care resources. Trauma is the leading cause of death for those ≤45 y, and it remains the third leading cause of death for those 45–64 y and eighth for those ≥66 y [11]. Among unintentional injury deaths, fall is the 10th leading cause for 25–34 y olds but steadily increases with each decade of life to replace motor vehicle crash as the number one cause of unintentional injury deaths by the sixth decade of life. According to the Center for Disease Control, in 2010, there were 26,009 deaths as a direct result of falls [5].

A longitudinal study >16 y showed that falls from ladders account for an average of 136,118 emergency department visits annually in the United States, which translated to an average of 49.5 per 100,000 people per year [12]. At our institution, falls from ladders corresponded to 1.3% of the trauma evaluations over the study period. The mean age in our population was 55.6 ± 14.8 y, which is about a decade older than in other studies [2,12]. This difference may be explained by regional demographic differences as Tucson has several retirement subsidiary communities and hosts an influx of older winter visitors. Consistent with other studies on this subject, our population was predominantly male (89.3%) [1,2,8].

We believe this is an important topic because injuries sustained as a result of falls from ladders are potentially preventable. In a retrospective study in which structured telephone interviews were also conducted to identify circumstances of the fall, Partridge found that most individuals who fell did not have anybody else assisting. It pinpointed incorrect ladder placement and excessive reaching as the most common reasons for such falls [2]. Nearly 70% of ladder falls in those aged 46–65 y and 90% of those >66 y took place at home, thus reinforcing the idea that the aging population is especially vulnerable because they may not have anybody else assisting.

Overall, the injury patterns we have identified from falls from ladders in our study are consistent with the patterns found in prior studies. In our study, thoracic and spine injuries were the most common injuries sustained after falls from ladders, affecting 29% and 26% patients, respectively. The remaining injuries in order of decreasing frequency were head (n = 66, 19.41%); lower-extremity fractures (n = 64, 18.82%); upper-extremity fractures (n = 60, 17.65%); pelvic fractures (n = 34, 10%); and intra-abdominal injuries (n = 25, 7.35%). The injury distribution in our study varied slightly from the largest study to date on this subject by D'Souza *et al.* Both studies found that fractures were the most common injury type. However, using the National Electronic Injury Surveillance System (NEIS) database with 136,118 patients treated over a 16-y period, D'Souza *et al.* [12] found the most frequently injured body parts were lower and upper extremities, which accounted for 30% and 22%, respectively. We believe the different findings were the result of differences in injury classification and the fact that the NEIS database does not provide injury information to the detail that we were able to generate from a detailed chart review. Thoracic and spine injuries are not categories specifically captured by the NEIS. Richter *et al.*, in a study of 101 fall patients including accidental and suicide from an average height of 24 ft, found that 83% of injuries involved the thoracic and lumbar region, particularly the thoracolumbar junction. Our study, with a more specific patient population of only falls from ladders, also found the thoracic and lumbar spine to be the most frequently injured part of the spine. Both studies, despite the significant difference in height of the fall, found that blunt abdominal injuries were relatively rare [13].

Prior studies have examined the injury pattern from falls as it relates to age, although these falls encompassed other falls that were not from ladders. In a study on falls >15 ft, Demetriades *et al.* found an increased incidence of pelvic fractures, femur fractures, and spinal injuries in the elderly patient population [5]. Sterling *et al.*, in a study on geriatric (>65 y old) falls, reported a higher incidence of head and/or neck, chest, pelvic, and extremity injuries when compared with the cohort group [3]. To our knowledge, no other studies have addressed the specific injury patterns of falls from ladders as it relates to age.

In our study, increasing age was associated with a decrease in the mean ladder fall height but worsening injury severity. Moreover, patients ≥66 y were four times more likely to sustain ISS >15 compared with the reference group of 18–45 y. Patients ≥66 y were also 3.4 times more likely to sustain head injuries and 2.7 times more likely to sustain thoracic injuries when compared with the reference group. Radius and ulna fractures, which comprise the most common upper-extremity fractures, were least common in patients ≥66 y (OR, 0.35; 95% CI, 0.13–0.96). We suspect this difference in injury pattern may be because of the body position at the time of impact with the ground as a result of reaction time differences between the age groups. Younger patients, alarmed by the momentary instability on the ladder immediately before the fall, may react instinctively with outstretched arms in attempt to brace their impact and prevent head and torso injuries. Older patients, with slower reaction times, may not react quickly enough and impact the ground largely with the torso and head. A study by Lapostolle *et al.* [14] suggested, which body parts impacted the ground first after falls from >3 m (9.8 ft) directly correlated with mortality. We suspect the same variable would affect injury pattern and severity as well. This proposal makes intuitive sense, but needs scientific validation on age-related fall mechanics.

The overall mortality rate in our study was 3.8% (n = 13). Although all deaths occurred in the latter two age groups, there was no statistical difference in mortality among the age groups. This is counterintuitive considering increasing age was associated with higher ISS, more head and truncal injuries resulting in increased need for hospital admission. We believe this may be a type 2 error due to the small sample size. The exact reason for admission was unknown, but almost half of the patients who were admitted had an operation. Among those who were admitted, the elderly seemed to have a higher incidence of head injury. Other reasons for admission, which would have been more difficult to extract, could have included pain control, monitoring of neurologic status, and respiratory care for those with rib fractures.

Our study has several limitations. First, its retrospective nature is associated with certain inherent inaccuracies of data collection. The fall height, although a statistically significant finding as it related to injury pattern, was based on patient and family member report. Our sample size of 340 patients may be underpowered to detect significant differences in mortality from ladder falls as a function of age.

In conclusion, patients ≥66 y are a particularly vulnerable population after falls from ladders. Although older patients fell from ladders at lower heights, they sustained more severe injuries with higher admission rates. The injury pattern changed with increasing age with younger patients sustained more hand and forearm fractures and older patients more traumatic brain injuries and truncal injuries. In older patients, most of the falls happen at home without the occupational safety resources available in the work environment [15]. A special effort needs to be made to reach out to this high-risk population. Public education concerning safe ladder use should be tailored to all individuals, particularly the elderly.

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Table 1

Location of falls.

Location	Age group, y			Total
	18–45	**46–65**	**>66**	
Home	32 (39)	122 (69)	74 (90)	228 (67)
Workplace/farm	17 (21)	15 (9)	0 (0)	32 (9)
Public/street	11 (13)	10 (6)	2 (2)	23 (7)
Other	22 (27)	29 (16)	6 (7)	57 (17)
Total	82 (100)	176 (100)	82 (100)	340 (100)

Data are represented as *n* (%).

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Table 2

Fall from ladder demographics and outcomes.

Outcomes	**Age group, y**			**Total**
	18–45	**46–65**	**≥66**	
Mortality, *n* (%)	0 (0)	8 (4.6)	5 (6.1)	13 (3.8)
OR (95% CI)	—	—	0.7 (0.2–2.3)	
Required admission, *n* (%)	45 (54.9)	136 (77.2)	72 (87.8)	253 (74.4)
OR (95% CI)	1.0	2.8 (1.6–4.9)	5.9 (2.7–13.1)	
Hospital length of stay, d (SD)	4.3 (4.0)	5.6 (7.3)	7.7 (8.5)	6.0 (7.3)
P value	—	0.33	0.002	
Admitted to ICU, *n* (%)	13 (15.9)	49 (27.8)	36 (43.9)	98 (28.8)
OR (95% CI)	1.0	2.0 (1.04–4.0)	4.2 (2.0–8.7)	
ICU length of stay, d (SD)	3.2 (3.4)	3.9 (6.8)	5.0 (6.4)	4.2 (6.2)
P value	—	0.96	0.34	
Ventilator days, d (SD)	2.4 (3.4)	2.0 (4.7)	3.1 (5.7)	6.0 (6.1)
P value	—	0.87	0.61	
Mean fall height, ft (SD)	12.6 (7.2)	9.4 (4.8)	7.8 (3.0)	9.8 (5.5)
P value	—	<0.0001	<0.0001	
Mean ISS (SD)	7.8 (6.8)	10.7 (9.1)	13.1 (8.1)	10.6 (8.6)
P value	—	<0.03	<0.001	
More than one injury*, *n* (%)	20 (24.4)	65 (36.9)	38 (46.3)	123 (36.2)
OR (95% CI)	1.0	1.8 (1.0–3.3)	2.7 (1.4–5.2)	
ISS ≥ 15, *n* (%)	9 (11.0)	36 (20.5)	26 (31.7)	71 (20.9)
OR (95% CI)	1.0	2.1 (1.0–4.6)	3.8 (1.6–8.7)	

ICU = Intensive-care Unit; SD = Standard Deviation.

*Abbreviated ISS ≥2 in more than one region.

Table 3

Incidence of injuries by anatomic location.

Location	%	*n*
Head injuries	19.4	66
Spine injuries	25.9	88
Cervical spine fractures	3.2	11
Thoracic spine fractures	16.2	55
Lumbar spine fractures	12.6	43
Thoracic injuries	29.1	99
Intra-abdominal injuries	7.3	25
Pelvic fractures	10.0	34
Upper-extremity fractures	17.6	60
Humerus	3.5	12
Ulna/radius	12.9	44
Hand	2.6	9
Lower-extremity fractures	18.8	64
Femur	5.0	17
Tibia/fibula	11.5	39
Foot	4.4	15

Table 4

Nonextremity injuries, by age group.

Location	**Age group, y**	***n* (%)**	**OR (95% CI)**
Head injuries	18–45	9 (11.0)	1.0
	46–65	33 (18.8)	1.9 (0.9–4.1)
	≥66	24 (29.3)	3.4 (1.5–7.8)
Spine injuries	18–45	18 (22.0)	1.0
	46–65	44 (25.0)	1.2 (0.6–2.2)
	≥66	26 (31.7)	1.7 (0.8–3.3)
Thoracic injuries	18–45	15 (18.3)	1.0
	46–65	53 (30.1)	1.9 (1.0–3.7)
	≥66	31 (37.8)	2.7 (1.3–5.6)
Abdominal injuries	18–45	6 (7.3)	1.0
	46–65	10 (5.7)	0.8 (0.3–2.2)
	≥66	9 (10.0)	1.6 (0.5–4.6)
Pelvic fractures	18–45	7 (8.5)	1.0
	46–65	17 (9.7)	1.2 (0.5–2.9)
	≥66	10 (12.2)	1.5 (0.5–4.1)
Truncal injuries	18–45	32 (39.0)	1.0
	46–65	90 (51.1)	1.6 (0.9–2.8)
	≥66	48 (58.5)	2.2 (1.2–4.1)

Table 5

Spine injuries, by age group.

Location	Age group, y	*n* (%)	OR (95% CI)
Generalized spine injuries	18–45	18 (22.0)	1.0
	46–65	44 (25.0)	1.2 (0.6–2.2)
	≥66	26 (31.7)	1.7 (0.8–3.3)
Cervical spine fractures	18–45	0	0 (0–∞)*
	46–65	6 (3.4)	0.5 (0.2–1.8)*
	≥66	5 (6.1)	1.0
Thoracic spine fractures	18–45	12 (14.6)	1.0
	46–65	29 (16.5)	1.2 (0.6–2.4)
	≥66	14 (17.1)	1.2 (0.5–2.8)
Lumbar spine fractures	18–45	9 (11.0)	1.0
	46–65	20 (11.4)	1.0 (0.5–2.4)
	≥66	14 (17.1)	1.7 (0.7–4.1)

*ORs indicated use ≥66 group as reference.

Table 6

Extremity injuries, by age group.

Location	Age group, y	*n* (%)	OR (95% CI)
Upper-extremity fractures	18–45	18 (22.0)	1.0
	46–65	31 (17.6)	0.8 (0.4–1.5)
	≥66	11 (13.4)	0.6 (0.2–1.3)
Humerus fractures	18–45	0	0 (0–∞)*
	46–65	8 (4.6)	0.9 (0.3–3.2)*
	≥66	4 (4.9)	1.0
Ulna/radius fractures	18–45	15 (18.3)	1.0
	46–65	23 (13.1)	0.7 (0.3–1.4)
	≥66	6 (7.3)	0.4 (0.1–0.96†)
Hand fractures	18–45	5 (6.1)	1.0
	46–65	2 (1.1)	0.2 (0–0.9)
	≥66	2 (2.4)	0.4 (0.1–2.0)
Lower-extremity fractures	18–45	12 (14.6)	1.0
	46–65	35 (19.9)	1.5 (0.7–3.0)
	≥66	17 (20.7)	1.5 (0.7–3.4)
Femur fractures	18–45	2 (2.4)	1.0
	46–65	7 (4.0)	1.7 (0.3–8.1)
	≥66	8 (9.8)	4.3 (0.9–21.0)
Tibia/fibula fractures	18–45	9 (11.0)	1.0
	46–65	25 (14.2)	1.3 (0.6–3.0)
	≥66	5 (6.1)	0.5 (0.2–1.7)
Foot fractures	18–45	4 (4.9)	1.0
	46–65	7 (4.0)	0.8 (0.2–2.8)
	≥66	4 (4.9)	1.0 (0.2–4.1)

* ORs indicated use ≥66 group as reference.

† Rounded to second decimal to show statistical significance.