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Research

Fall from standing height, or greater, and mortality among ambulance-transported patients with major trauma from falls

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Abstract

Introduction
This study describes the relationship between falls from standing height, or greater, and mortality in ambulance-transported patients with major trauma from falls.

Methods
Road ambulance records from 1 January 2013 to 31 December 2016 were linked with WA State Trauma Registry records to identify ambulance-transported falls patients with major trauma.

Results
Of the patients who fell from standing level, 114/460 (25%) died within 30 days, compared with 47/222 (21%) who fell from height (p=0.64).

Conclusion
Mortality is relatively high, and fall height is not associated with 30-day survival, among ambulance-transported patients with major trauma in metropolitan Perth, Western Australia.

Keywords:
emergency medical services; survival

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Introduction

Falls affect people of all ages but are of particular concern among the elderly. The risk of serious injury or death from a fall increases with age, as does the frequency of falls (1). The number of people in Western Australia (WA) 65 years of age or over has more than doubled in the past 20 years (2), now exceeding half a million persons, and there are more than 28,000 ambulance-attended falls-related incidents in WA each year (3). Falls have a higher risk of death than other causes of major trauma (1). A recent study of ambulance-transported patients identified falls as the most common cause of major trauma in metropolitan Perth (4). Our study further examines the falls sub-group (4).

Fall height has been found to reliably predict severity of injury (5). A review of admissions to a major trauma unit in England identified that falls from standing height or less (including falls from chairs or beds) accounted for 16% of all spinal fractures, and that increased age was associated with mortality (6). In adults more than 65 years of age who fall, 90% of fractures involve falls from standing height or lower (8). In Victoria it was found among 678,654 fall incidents attended by emergency medical services, the median age of male patients was significantly lower than that of female patients (81 vs. 85 years, $p<0.0001$), and that 73% of 3294 ambulance-attended patients who had fallen from a ladder were male (7). Depending upon the height of the fall, physiology of the person falling and the landing interaction between the faller and landing zone, the kinetic energy of impact after falling from a standing position ranges between 100 and 400 J (9). It follows then that if fall height is greater than from standing, the kinetic energy at impact would tend to be greater. However, falls with equivalent impact energy may not affect people of different ages in the same way. Falls of all ages often result in impact to the hip yet, in addition to age associated characteristics of bone density, the scarcity of hip fractures in young adults is thought partially attributable to faster reaction times, resulting in protective stepping attempts to regain balance and the distribution of energy to outstretched hands (10). Outstretched hands are an instinctive mechanism to protect the head, though the energy-absorbing capacity of the upper limbs decreases with age, resulting in a decrease in wrist fractures after falling in adults 70 years of age or more (11) and an increase in rates of traumatic brain injury from falls (12).

Given their high mortality, falls resulting in major trauma are especially important to characterise and, yet, the picture of community-based falls is largely incomplete. Patients who initially survive major trauma due to falls may vary from a young, otherwise healthy person who has fallen from height, to an elderly person who was at increased risk that a fall would lead to haemorrhage, due to being on antiplatelet or anticoagulant medications (1). This clinical diversity could be a significant factor when interpreting short-term mortality of initial survivors of major trauma due to falls. Therefore, the aim of this study was to describe the demographic and injury characteristics of a cohort of patients with major trauma due to falls who were transported to hospital by ambulance. Of particular interest was to explore the relationship between falls from standing height, or greater, and 30-day mortality.

Methods

Perth is serviced by a single emergency road ambulance provider, St John WA (SJWA). Of the four tertiary and six secondary hospitals in Perth, five provide data to the WA State Trauma Registry (4). The clinical cohort described in this study was SJWA ambulance-transported patients with WA State Trauma Registry records of major trauma from falls and injury severity score (ISS) greater than 15 (4).

Trauma registry data from 1 January 2013 to 31 December 2016 were linked to SJWA electronic patient care records data using probabilistic matching (FRIL ver. 2.1.5, Emory University and Centers for Disease Control and Prevention, Atlanta, Georgia, US). Using date of birth, first name and surname, and residential address, data were initially deterministically, then probabilistically, linked. Links were manually checked when close to, but below, a pre-determined threshold. Failure to link occurred when data were incomplete in either record.

In the trauma registry data, up to six body regions were scored using an abbreviated injury scale. When there were multiple injuries then the maximum three abbreviated injury scale scores were squared and summed to calculate Baker's ISS, (13) with major trauma conventionally defined as injuries with an ISS greater than 15 (14).

Only falls patients aged 16 years and more were transported by ambulance in the Perth metropolitan area and who were listed in the WA State Trauma Registry were included. Patients who died at the scene were excluded by not being transported nor listed in the trauma registry, as were patients who arrived at hospital by other means of transport, and cases involving hanging, drowning or poisoning, as per the WA Department of Health definition of trauma (15).

Falls were identified through the trauma registry code for mechanism of injury, which has three related categories entered from chart review: (a) falls from standing height, (b) falls from above the ground but less than 3 metres height, and (c) falls from greater than 3 metres. For analysis, we dichotomised this into falls from standing height, and falls from any height above the ground. Survival at 30 days was also obtained from the WA State Trauma Registry records.

The data were stored in and analysed using the Statistical Package for the Social Sciences (SPSS®) ver 24.0 (IBM, Armonk, NY). Figures were compiled using MS Excel®. Counts are reported with percentages, means with standard deviations (SDs) and medians with interquartile ranges (IQRs). Differences in median age were tested using Mood's median test. Age and

gender, location (residential care vs. other), fall height and binary interactions between age, gender and fall height were fitted into a binary logistic regression model with mortality at 30 days as the dependent variable. The model was optimised through backwards elimination. Univariate differences between binary sub-groups (ie. fall height vs. 30-day mortality) were assessed using chi-square tests. Significance was accepted at $p<0.05$.

Results

Of the 682 patients, 371 (54%) had an ISS of 16 to 24, 303 (44%) had an ISS of 25 to 50, and eight (1%) had an ISS of 50 or greater. Median age was 66 years (IQR 31) for males (n=410, 60%), 81 years (IQR 20) for females ($p<0.0001$). Ninety-five patients (14%) were located at residential care facilities. Of the patients who fell from standing level, 114/460 (25%) died within 30 days compared with 47/222 (21%) who fell from height ($p=0.64$). Of the 222 falls from height, 92 (41%) were from more than 3 metres. Fall from height had no association with mortality by 30 days ($p=0.64$, OR=0.9, 95% CI 0.6, 1.4) among patients who were transported (ie. who did not die at the scene).

Compared with falls from height, falls from standing level were more likely to suffer a head injury ($p=0.003$). Among all head injuries, those associated with falling from standing level were more likely than those associated with falling from height to be scored as severe (42% vs. 25%, $p<0.0001$) or critical (42% vs. 25%, $p<0.0001$). Falls from height, however, were more likely to result in an injury to the face ($p=0.004$), chest ($p<0.001$), abdomen ($p<0.001$), and extremities ($p<0.001$). There was no difference between fall height (standing vs. height) in the percentage of patients with an ISS of 16 to 24 (54% both groups) or ISS of 25 or greater (46% both groups). Table 1 presents the division of patients by age, gender and fall height.

Table 1. Division of patients by age, gender and fall height, with 30-day mortality

Gender	Age (years)	Fall height	N (%)	Mortality 30 (%) *
Male	≥65	Standing	162 (24)	45/162 (28)
		>Standing	60 (9)	20/60 (33)
	<65	Standing	76 (11)	14/76 (18)
		>Standing	112 (16)	15/112 (13)
Female	≥65	Standing	196 (29)	51/196 (26)
		>Standing	21 (3)	6/21 (29)
	<65	Standing	26 (4)	4/26 (15)
		>Standing	29 (4)	6/29 (21)
Total			682 (100)	161/682 (24%)

*Proportion and percentage of each respective sub-group (age, gender and fall height) that died within 30 days

Table 2 presents discharge and 30-day mortality by ISS severity. Median length of stay in hospital was 7 days (IQR 3-13) before discharge or death. Of the variables age, gender, fall height and residence in residential care facility, only age was significantly associated with 30-day mortality (OR 1.17 per additional 10 years of age, 95% CI 1.06, 1.29, $p=0.001$).

Table 2. Disposition among ambulance-transported patients with major trauma from falls (n=682)

Disposition	ISS 16-24 (n=371) N (%)	ISS ≥25 (n=311) N (%)	Overall (n=682) N (%)
Survived to hospital discharge	341 (92)	180 (58)	521 (76)
Death by 30 days	30 (8)	131 (42)	161 (24)
Total	371	311	682 (100)

ISS = injury severity score

Ethics

Human Research Ethics Committee approval was obtained from Curtin University (HR 128/2013), Royal Perth Hospital Human Research Ethics Committee (PRN 464) and the SJWA Research Governance Committee.

Discussion

The main findings of this study are twofold; first, falls from standing height that result in major trauma and ambulance transport are an important group of patients with relatively higher mortality than might be expected based on fall height alone. Second, in this specific cohort mortality among falls from standing height was similar to that among falls from greater height ($p=0.64$). This differs to the Alizo et al study, in which only high-level falls greater than 10 feet (3 metres) were included (5).

Age was associated with 30-day mortality (OR 1.17 per additional 10 years of age), though this specific cohort of patients may not be representative of the wider population of people who fall, especially among those whom were not transported, or not transported to a trauma centre. Falls that were immediately fatal, for example, would have been excluded from our data as would patients transported to hospitals that do not report to the WA State Trauma Registry. Even so, with an aging population it may prove to be that 30-day mortality among ambulance-attended falls patients will also rise in future years. Other limitations of this study have been described previously (4) and include that unknown potential confounders (eg. comorbidities) are not accounted for in these data, and that the data are subject to survivor bias.

In the present study, ambulance-transported major trauma patients injured by falls from standing height had significantly more head injuries than ambulance-transported patients who fell from greater heights. Additionally, in this study cohort falls from standing height were proportionally more common in female patients than in males. Moreover, males were also younger

than females (66 years vs. 81 years, p<0.0001). Given the association between age and comorbidities, future work should investigate comorbidities in patients with major trauma from falls.

Conclusion

Mortality is relatively high among ambulance-transported patients with major trauma from falls in metropolitan Perth, WA. Moreover, 30-day survival was not associated with fall height, being from either standing height or less, or from greater than standing height. Age, however, was associated with 30-day mortality, though it remains to be determined what effects upon mortality existing comorbidities had, in this particular cohort.

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Competing interests

Paul Bailey is the Clinical Services Director for SJWA. Judith Finn receives research support from SJWA. Each author of this paper has completed the ICMJE conflict of interest statement.

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