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Original Research

Risk factors and complications contributing to mortality in elderly patients with fall-induced femoral fracture: A cross-sectional analysis based on trauma registry data of 2,407 patients

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ABSTRACT

Background: This study aimed to identify the risk factors and complications associated with mortality in elderly patients with femoral fracture after a fall from the ground level.

Methods: This retrospective study reviewed data pertaining to elderly patients aged ≥65 years who were admitted into a Level I trauma center, between January 1, 2009 and December 31, 2017. Multivariate logistic regression analysis was performed to identify independent effects of univariate predictive variables on the occurrence of mortality.

Results: Of 2407 enrolled elderly patients, there were 42 mortal and 2365 survival patients. A greater percentage of fatal patients than survival patients had a head injury with abbreviated injury scale (AIS) score ≥ 2 in the head/neck region (4.8% vs. 0.7%, respectively; p = 0.042). Multivariate logistic regression analysis revealed that the age (odds ration [OR] 1.1, 95% confident interval [CI] 1.0–1.1, p < 0.001), pre-existence of end-stage renal disease (ESRD) (OR 3.2, 95% CI 1.2–8.7, p = 0.023), and subarachnoid hemorrhage (SAH) (OR 12.1, 95% CI 1.3–113.9, p = 0.029) were significant independent risk factors for mortality in elderly patients with a femoral fracture resulting from a ground level fall. The patients in mortality group had a significantly higher rates of pneumonia (OR 28.6, 95% CI 14.6–55.9, p < 0.001), respiratory failure (OR 68.7, 95% CI 32.2–146.4, p < 0.001), sepsis (OR 26.3, 95% CI 10.9–63.4, p < 0.001), and pulmonary embolism (OR 14.4, 95% CI 1.6–131.6, p = 0.002) than those in the survival groups.

Conclusions: This study identified age, pre-existence of ESRD, and SAH as significant independent risk factors for mortality in elderly patients with femoral fracture in a fall. However, ESRD and SAH only contribute to the mortality in a small group of patients. In contrast, respiratory complications contributed greatly to mortality. Thus aggressive chest-protective measures are encouraged to decrease the respiratory complications associated with femoral fracture in elderly patients.

1. Introduction

Falls are a main cause of morbidity and disability in the elderly [1,2]. Around 30% of people over 65 years of age fall each year [3], and half of such cases the falls are recurrent [1]. The elderly are at an especially high risk of death after a fall [4]. An estimated 55% of all unintentional injury-related deaths among the elderly over 65 years of age are due to falls [5]. In a population-based retrospective cohort study of 312,758 hospitalizations, the 30-day mortality rate after falls was 2.9–4.2% [6].

Consequences of falls in the elderly often include fractures, immobility, impairment, and sometimes death. Falls are also the major cause of femoral fractures in the elderly [7,8]. Among 261 retrospectively analyzed fatal falls of elderly individuals over 65 years of

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age, the most severely injured body region was the head, followed by the hip [4]. However, hip fracture was the only serious injury leading to hospitalization and death [4]. It was estimated by a cross-sectional population-based study that 5.5% of elderly patients with a diagnosis of fall-related hip fracture died during hospitalization [9]. With osteoporotic bone changes occurring in patients with increasing age, even a fall from ground level is associated with an increased rate of femoral fracture and risk of mortality [10]. In Taiwan the total number of hip fractures increased steadily from 12,479 to 19,841 cases annually from 1996 to 2010 [11]. The hip fractures with subsequent morbidity are also increasing in Taiwan as that occurred in the aging society of other countries [12]. However, the Taiwanese population had among the highest hip fracture rates in the world [13]. The average female-to-male ratio of hip fracture in Taiwanese population was about 1.6–1.8, lower than those in many countries [13,14]. In addition, the men had higher mortality rates in hospital than the women, albeit the latter outnumbered men in all types of hip fractures [11]. Therefore, we aimed to determine the risk factors and complications contributing to mortality in elderly Taiwanese patients with femoral fracture after a fall from ground level.

2. Methods

2.1. Data extraction

This was a retrospective study and the work has been reported with the STROCSS criteria [15] and has been submitted to ClinicalTrials.gov that Unique Identifying Number is NCT03800186. The medical records of a total of 27,462 enrolled trauma patients registered between January 1, 2009 and December 31, 2017 in the Trauma Registry System [16–18] were reviewed for this study. The inclusion criteria were age ≥65 years and hospitalization for the treatment of femoral fracture following a fall from standing height level (< 1 m). This study excluded those patients with a fall from ≥1 m as well as those for whom incomplete data were available. Retrieved patient data included age; sex; pre-existing comorbidities such as cerebral vascular accident (CVA), hypertension (HTN), coronary artery disease (CAD), congestive heart failure (CHF), diabetes mellitus (DM), and end-stage renal disease (ESRD); abbreviated injury scale (AIS) score; injury severity score (ISS) expressed as median and interquartile range (IQR; Q1–Q3); Glasgow coma scale (GCS) score; occurrence of subdural hemorrhage (SDH), subarachnoid hemorrhage (SAH), intracerebral hemorrhage (ICH), or epidural hemorrhage (EDH) on brain computed tomography (CT); length of stay (LOS) in hospital; admission into an intensive care unit (ICU); in-hospital mortality; and cause of mortality.

2.2. Statistical analysis

SPSS for Windows version 22.0 (IBM Corp., Armonk, NY, USA) was used for the statistical analysis. The categorical variables were analyzed using Pearson's chi-squared test or Fisher's exact test and are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The continuous variables were estimated using Levene's test for homogeneity of variance, analyzed using one-way analysis of variance with a Games–Howell post-hoc test, and expressed as mean ± standard deviation. Multivariate logistic regression analysis was applied to identify independent effects of univariate predictive variables on the occurrence of mortality for elderly patients after a fall. P values < 0.05 were considered statistically significant.

3. Results

3.1. Patient characteristics and outcomes

A total of 2407 elderly patients with femoral fracture resulting from a fall were included in this study (Fig. 1). Patients were categorized into

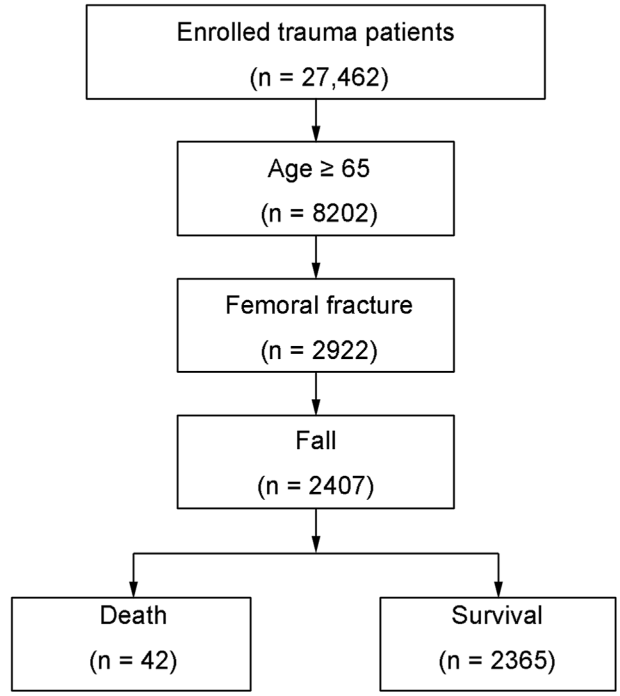

Fig. 1. Flow chart of the inclusion of elderly trauma patients who sustained a femoral bone fracture in a fall.

Table 1
Characteristics and outcomes of elderly patients who sustained a fall-induced femoral fracture.

Variables	Death n = 42		Survival n = 2365		P
Age (years)	83.6	± 7.8	79.6	± 7.2	< 0.001
Gender					1.000
Male, n (%)	12	(28.6)	663	(28.0)	
Female, n (%)	30	(71.4)	1702	(72.0)	
Co-morbidities					
CVA, n (%)	6	(14.3)	363	(15.3)	1.000
HTN, n (%)	32	(76.2)	1602	(67.7)	0.317
CAD, n (%)	8	(19.0)	261	(11.0)	0.131
CHF, n (%)	1	(2.4)	71	(3.0)	1.000
DM, n (%)	19	(45.2)	790	(33.4)	0.137
ESRD, n (%)	5	(11.9)	111	(4.7)	0.049
ISS (median, IQR)	9	(9-9)	9	(9-9)	0.334
GCS (median, IQR)	15	(15-15)	15	(5–15)	0.166
1–8, n (%)	0	(0.0)	6	(0.3)	1.000
9–12, n (%)	3	(7.1)	43	(1.8)	0.045
13–15, n (%)	39	(92.9)	2316	(97.9)	0.060
AIS ≥ 2					
Head/Neck, n (%)	2	(4.8)	17	(0.7)	0.042
Face, n (%)	0	(0.0)	6	(0.3)	1.000
Thorax, n (%)	0	(0.0)	19	(0.8)	1.000
Abdomen, n (%)	0	(0.0)	22	(0.9)	1.000
SDH, n (%)	2	(4.8)	11	(0.5)	0.021
SAH, n (%)	2	(4.8)	5	(0.2)	0.006
ICH, n (%)	0	(0.0)	4	(0.2)	1.000
EDH, n (%)	0	(0.0)	0	(0.0)	–
LOS in hospital, days	22.1	± 22.4	9.1	± 6.7	0.001
ICU, n (%)	26	(61.9)	187	(7.9)	< 0.001

CAD = coronary artery disease; CHF = congestive heart failure; CI = Confidence interval; CVA = cerebral vascular accident; DM = diabetes mellitus; EDH = epidural hemorrhage; ESRD = end-stage renal disease; GCS = Glasgow Coma Scale; HTN = hypertension; ICH = intracerebral hemorrhage; ICU = Intensive care unit; IQR = Interquartile range; ISS = Injury Severity Score; LOS = Length of stay; OR = Odds ratio; SAH = subarachnoidal hemorrhage; SDH = subdural hemorrhage.

Table 2
Risk factors influencing mortality in elderly patients with a fall-induced femoral fracture analyzed using univariate and multivariate logistic regression.

Variables	Univariate analysis			Multivariate analysis		
	OR (95% CI)		P	OR (95% CI)		P
Age (years)	1.1	(1.0–1.1)	< 0.001	1.1	(1.0–1.1)	< 0.001
Gender (male)	1.0	(0.5–2.0)	0.939	–		–
Co-morbidities						
CVA	0.9	(0.4–2.2)	0.850	–		–
HTN	1.5	(0.8–3.1)	0.248	–		–
CAD	1.9	(0.9–4.1)	0.108	–		–
CHF	0.8	(0.1–5.8)	0.815	–		–
DM	1.6	(0.9–3.0)	0.111	–		–
ESRD	2.7	(1.1–7.1)	0.038	3.2	(1.2–8.7)	0.023
ISS	1.1	(1.0–1.2)	0.087	–		–
SAH	23.6	(4.5–125.3)	< 0.001	12.1	(1.3–113.9)	0.029
SDH	10.7	(2.3–49.9)	0.003	3.3	(0.4–29.6)	0.283

CAD = coronary artery disease; CHF = congestive heart failure; CI = Confidence interval; CVA = cerebral vascular accident; DM = diabetes mellitus; ESRD = end-stage renal disease; GCS = Glasgow Coma Scale; HTN = hypertension; IQR = Interquartile range; ISS = Injury Severity Score; OR = Odds ratio; SAH = Subarachnoid hematoma; SDH = Subdural hematoma.

two groups: mortality ($n = 42$) and survival ($n = 2365$). As shown in Table 1, the patients were significantly older in the mortality group than in the survival group (83.6 ± 7.8 vs. 79.6 ± 7.2, respectively; $p < 0.001$). There were no significant intergroup differences in the prevalence of sex or pre-existing comorbidities except for a significantly higher rate of ESRD in the mortality group than the survival group (11.9% vs. 4.7%, respectively; $p = 0.049$). No significant intergroup difference was found in ISS or GCS scores. However, a greater percentage of fatal patients than survival patients had a GCS score of 9–12 (7.1% vs. 1.8%, respectively; $p = 0.045$) and an AIS score ≥2 in the head/neck region (4.8% vs. 0.7%, respectively; $p = 0.042$). Among these patients, the rates of SDH (4.8% vs. 0.5%; $p = 0.021$) and SAH (4.8% vs. 0.2%; $p = 0.006$) were significantly higher in the mortality group than the survival group, respectively. Notably, none of the patients in the mortality group had an AIS score ≥2 injury to the face, thorax, or abdomen and none had ICH or EDH. The patients in the mortality group had a longer LOS in the hospital (22.1 days vs. 9.1 days; $p = 0.001$) and a higher rate of ICU admission (61.9% vs. 7.9%; $p < 0.001$) than those patients in the survival group, respectively.

3.2. Risk factors for mortality

The univariate logistic regression analysis (Table 2) demonstrated that age, pre-existing ESRD, and the occurrence of SAH and SDH were significant risk factors for mortality in elderly patients with a fall-induced femoral fracture. In contrast, sex, other pre-existing co-morbidities except ESRD, and ISS were not significant risk factors for mortality. The multivariate logistic regression analysis revealed that the age (OR, 1.1; 95% CI, 1.0–1.1; $p < 0.001$), pre-existing ESRD (OR, 3.2; 95% CI, 1.2–8.7; $p = 0.023$), and SAH (OR, 12.1; 95% CI, 1.3–113.9; $p = 0.029$) were significant independent risk factors for mortality in elderly patients with a ground level fall–induced femoral fracture. As shown in Table 3, an analysis of the cause of mortality revealed that the patients in mortality group had significantly higher rates of pneumonia (OR, 28.6; 95% CI, 14.6–55.9; $p < 0.001$), respiratory failure (OR, 68.7; 95% CI, 32.2–146.4; $p < 0.001$), sepsis (OR, 26.3, 95% CI 10.9–63.4, $p < 0.001$), and pulmonary embolism (OR 14.4, 95% CI 1.6–131.6, $p = 0.002$) than patients in the survival group. The causes of the fatality were associated with a deteriorated pulmonary condition.

4. Discussion

In this study, age, pre-existence of ESRD, and SAH were identified as significant independent risk factors for mortality in elderly patients with a fall-induced femoral fracture. However, gender did not lead to significant difference of mortality in the elderly, which is in contrast to the report that the men had higher mortality rates than the women by all causes in people aged 55 and over [11]. As expected, advanced age is closely associated with in-hospital mortality. This result is compatible to those that report age as the primary risk factor contributing to mortality in elderly patients with hip fractures of any traumatic cause [19]. In another study, age was the primary risk factor for mortality of patients older than 75 years during the first year after hip fracture [20]. Higher mortality rates were found in patients over 85 years than in those aged 75–85 years [20].

In this study, the second identified risk factor for mortality was the pre-existence of ESRD, as changes in bone metabolism are seen in patients with chronic kidney disease long before the initiation of renal replacement therapy [21]. Patients with chronic kidney disease suffer significant cortical bone loss mediated by hyperparathyroidism and elevated turnover [22]. It had been reported that individuals with chronic kidney disease have a subsequently higher fracture risk [22] long before the implementation of renal replacement therapy [23]. In addition, post-hip fracture mortality was increased in patients with stage 4 chronic kidney disease [23]. The 1-year mortality rate post-hip fracture is 55–64% for dialysis patients [24,25], which is a 2.7-fold increase over the non-fractured dialysis population [24,25].

The most serious consequences of falls include hip fractures and intracranial injury [26]. This study revealed that, in elderly patients with a fall-induced femoral fracture, the rates of SDH and SAH were significantly higher in the mortality group than in the survival group. In addition, SAH was a significant independent risk factor for mortality. However, of these 42 patients who died, only 2 had SAH. Furthermore, in this study, a greater percentage of fatal patients than survival patients had an AIS score ≥2 in the head/neck region (4.8% vs. 0.7%, respectively; $p = 0.042$). The actual number of patients who died from intracranial injury in a ground level fall was small. This result is in accordance with the observation that hip fracture was the only serious injury leading to hospitalization and death among 261 fatal falls of elderly patients aged ≥65 years, although 62% of patients who fell from stairs height and 49% who fell from ground level height suffered head injuries [4].

Notably, the identified independent risk factors (ESRD, SAH) in this study contributed to mortality in only a small group of patients. In contrast, the respiratory complications sustained in the elderly patients with a ground level fall–induced femoral fracture contributed greatly to mortality. A lung capillary leak with increased neutrophil content was

Table 3
Causes of mortality in elderly patients with a fall-induced femoral fracture.

Variables	Death n = 42		Survival n = 2365		OR (95%CI)		P
Pneumonia	17	(40.5)	55	(2.3)	28.6	(14.6–55.9)	< 0.001
Respiratory failure	16	(38.1)	21	(0.9)	68.7	(32.2–146.4)	< 0.001
Sepsis	8	(19.0)	21	(0.9)	26.3	(10.9–63.4)	< 0.001
Pulmonary embolism	1	(2.4)	4	(0.2)	14.4	(1.6–131.6)	0.002

CI = Confidence interval; OR = Odds ratio.

reported in rats with femoral fractures [27]. In a follow-up of 1013 hip fracture patients at all ages and 2026 matched community controls over 22 years, cardiovascular disease and pneumonia were predominant causes of death [28]. In a study of 467 patients who underwent hip fracture surgery, the most common cause of mortality was pneumonia (37.1%, 13/35), followed by acute coronary syndrome (31.4%, 11/35) and sepsis (14.3%, 5/35) [29]. In the elderly, sepsis after hip fracture typically develops from among 3 potential infectious sources: urinary tract infection (1 in 3 patients), pneumonia (1 in 3 patients), and surgical site infection (1 in 15 patients) [30]. The mortality rate was significantly increased in those who developed sepsis than in those who did not (21.0% vs 3.8%; $p < 0.001$) [30]. In this study, pneumonia, respiratory failure, sepsis, and pulmonary embolism comprised most of the cases of mortality. The patients in the mortality group had significantly higher rates of pneumonia (OR, 28.6; 95% CI, 14.6–55.9; $p < 0.001$), respiratory failure (OR, 68.7; 95% CI, 32.2–146.4; $p < 0.001$), sepsis (OR, 26.3; 95% CI, 10.9–63.4; $p < 0.001$), and pulmonary embolism (OR, 14.4; 95% CI, 1.6–131.6; $p = 0.002$) than those patients in the survival group.

Obviously, avoiding falls in the elderly is the basic principle to preventing the occurrence of fracture and subsequent complications. It is estimated that up to 22% of the fatalities due to ground level falls may be avoided by preventing hip fractures using optimized hip protectors or other measures, especially for elderly individuals aged 75 + years [4]. However, once a femoral fracture occurs, the limited mobilization caused by the fracture compromises the daily activity of the patients and thus may be associated with fracture-related complication. Most hip fracture patients fail to regain their pre-fracture level of activities of daily living [31], and it is estimated that up to 20% of patients require institutionalization because of the fracture [31]. Even at 6 months postoperative, 24% and 33% of community-dwelling ambulatory patients and indoor ambulatory patients, respectively, were unable to regain their pre-injury ambulation level [32]. A cumulative incidence analysis revealed that mortality due to cardiorespiratory causes (pneumonia, myocardial infarction, cardiac failure) persists beyond 30 days after proximal femoral fracture surgery [29]. Therefore, to prevent femoral fracture–related complications in elderly individuals after a fall, continuing physiotherapy, respiratory exercises, and other chest-protective measures are needed. Respiratory function needs to be optimized with early intervention in patients with signs of cardiovascular compromise or infection. Elderly patients with a hip fracture and postoperative weight-bearing restrictions are at significantly greater risk of developing adverse events than those who are encouraged to bear weight as tolerated [33]. Compared with patients receiving intensive hospital rehabilitation, no rehabilitation showed significantly higher mortality risks (hazard ratio, 2.19; 95% CI, 1.54–3.12; $p < 0.001$) [34]. In addition, use of the orthopedic nurse practitioner hip fracture patients can reduce the acute hospital LOS and further complications [35].

This study has some limitations. First, its retrospective design may have resulted in bias. Second, the trauma registered data only included cases of in-hospital mortality but not data at 30 days or beyond; therefore, the results may not reflect the full scope of the mortality associated with fall-related femoral fracture in the elderly. Third, this study did not investigate the interventions provided to the patients; thus, the outcome measurements may be biased. In particular, it was reported that early surgery within 24 h may minimize complications secondary to immobilization, including orthostatic pneumonia and venous thromboembolism [36]. Fourth, this study did not cover a number of risk factors such as medication, blood transfusion, and coagulopathy that have been identified as contributors to mortality, which may have resulted in analysis bias. And finally, the population included in this study was limited to that of a single urban trauma center in southern Taiwan; as such, our results may not be applicable to a wider population.

5. Conclusion

This study identified that age, pre-existence of ESRD, and SAH were significant independent risk factors for mortality in elderly patients with a fall-induced femoral fracture. However, most fatalities were due to respiratory causes; thus, the use of chest-protective measures is encouraged to decrease such complications.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Conflicts of interest

Not applicable.

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Ethical approval

This study was pre-approved by the Institutional Review Board (IRB) of Chang Gung Memorial Hospital (approved number: 201800742B0). According to IRB regulations, the need for informed consent was waived.

Research registration Unique Identifying Number (UIN)

NCT03800186.
https://clinicaltrials.gov/ct2/show/NCT03800186.

Author contribution

YHY wrote the manuscript; CSR drafted and proof-read the manuscript; SCHK reviewed the literature; PCC performed the statistical analyses; HYH edited the tables; CHH designed the study and contributed to the analysis and interpretation of data. All authors read and approved the final manuscript.

Guarantor

Ching-Hua Hsieh.

Data statement

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

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