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Predictors for 1-year mortality in geriatric patients following fragile intertrochanteric fracture surgery

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Abstract

Objective To investigate the risk factors influencing 1-year mortality after intramedullary nail fixation for fragile intertrochanteric fracture in elderly individuals.

Methods The medical records of 622 consecutive elderly patients (aged ≥ 65 years) with fragile intertrochanteric fractures treated with proximal femoral nail anti-rotation (PFNA) and followed-up were retrospectively analyzed. The patients were divided into death and survival groups according to their survival status within 1 year after surgery, and the differences in age, sex, region of residence, tobacco use, alcohol use, body mass index (BMI), comorbidities (hypertension, diabetes mellitus, coronary heart disease, stroke, dementia, chronic obstructive pulmonary disease, pneumonia), preoperative hemoglobin, preoperative albumin, deep vein thrombosis, fracture type (AO classification), injury-to-surgery time, American Society of Anesthesiologists (ASA) score, anesthesia modality, duration of surgery, intraoperative blood loss, and blood transfusion were compared. The Kaplan–Meier method was used for univariate analysis to screen for statistically significant differences between the two groups, and the data were entered into the Cox proportional hazards model for multivariate analysis to determine independent risk factors affecting 1-year postoperative mortality. For subgroup analysis, we explored the varying effects of hypoproteinemia and being underweight in patients of different genders, as well as the effects of different age ranges, different injury-to-surgery times, and different blood transfusion volumes on 1-year postoperative mortality.

Results The mortality rates at 1, 3, and 6 months, and 1 year after surgery were 3.9%, 7.2%, 10.1%, and 15.3%, respectively. Univariate analysis showed that advanced age, male sex, tobacco use, underweight (BMI < 18.5), coronary heart disease, stroke, dementia, pneumonia, number of comorbidities ≥ 3, hypoproteinemia and injury-to-surgery time ≤ 2 days were associated with the 1-year postoperative survival status ($P < 0.1$). Multivariate analysis revealed that advanced age, male sex, dementia, number of comorbidities ≥ 3, hypoalbuminemia, and being underweight were independent risk factors for 1-year postoperative mortality. Subgroup analysis showed that being underweight was associated with 1-year postoperative mortality only in male patients but not in female patients, whereas hypoproteinemia was associated with 1-year postoperative mortality in both male and female patients. Furthermore, an injury-to-surgery time of less than 2 days improved patient survival, and patients more than 80 years old showed an elevated risk of postoperative mortality.

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Conclusions Preoperative health status is a critical predictor of postoperative outcomes in elderly patients with fragile intertrochanteric fractures. Priority care should be given to the patients who are elderly, male, have dementia, have comorbidities, or are malnourished. Prompt nutritional reinforcement should be provided to patients with intertrochanteric fractures with comorbid hypoproteinemia and underweight. Furthermore, surgery should be performed as early as possible in patients with fewer comorbidities.

Keywords Intertrochanteric fracture, Mortality, Risk factor, Albumin, Body mass index

Introduction

As the global population ages, the societal burden of hip fractures will continue to increase, with the total number of hip fractures occurring annually by 2050 projected to reach 1.9 times the number in 2018 [1]. The incidence of hip fractures increases significantly with age, with 87–96% of hip fracture patients reported to be 65 years of age or older [2]. The mortality rate is increased in the elderly due to the decline in physical function, which is often associated with more underlying diseases, the need for prolonged bed rest after injury, and exposure to a variety of factors, such as trauma reactions and fracture-related complications. The all-cause mortality rate at 1 year after hip fracture ranges from 14.4 to 28.3% across countries [1]. Although many studies have examined factors associated with postoperative mortality after hip fracture, most combined intertrochanteric and femoral neck fractures, which do not eliminate the interference of different fracture sites and surgical approaches on patient prognosis. Intertrochanteric and femoral neck fractures have different etiologies [3], surgical strategies [4], and prognoses. The short- [5] and long-term mortality rates [6, 7] are better for femoral neck fractures than intertrochanteric fractures. In addition, hip arthroplasty is associated with a higher mortality rate than internal fixation [8]. As a mainstream procedure for intertrochanteric fractures, intramedullary nail surgery has excellent biomechanical properties and is particularly suitable for elderly patients with osteoporosis [4, 9, 10]. This approach can facilitate early functional exercise and downward mobility of the patients, reduce the complications caused by prolonged bed rest, and improve the postoperative quality of life. Therefore, the aim of this study was to investigate the risk factors affecting 1-year mortality after PFNA fixation in elderly patients with fragile intertrochanteric fractures.

Methods

Study design and participants

This retrospective case-control study was conducted in the trauma center of the Affiliated Hospital of Jining Medical University. We collected medical data on all consecutive patients with intertrochanteric fractures who were treated with proximal femoral nail anti-rotation (PFNA, 135°, Kanghui Medical, China) at our trauma center from January 2015 to December 2022, including medical records, laboratory tests, and imaging examinations. The inclusion criteria were as follows: age ≥ 65 years; low-energy injury; unilateral intertrochanteric fracture; surgical treatment with PFNA; and patients with at least 1 year of follow-up or who died within 1 year. The exclusion criteria were as follows: pathological fracture; high-energy injury; combination of fractures at other sites; previous or current malignancy; previous treatment with hip surgery; and refusal of follow-up. All surgeries were performed by nine experienced trauma orthopedic surgeons. Two trauma orthopedic surgeons classified the fractures according to the AO criteria by reviewing the patients' X-rays and computed tomography (CT) scans without knowing their clinical characteristics. Cognitive status was assessed using the Mini-mental State Examination (MMSE), and dementia was diagnosed according to the patient's educational level. Dementia was classified according to the following criteria: illiteracy level ≤ 17 points, elementary school level ≤ 20 points, secondary school level (including technical secondary school) ≤ 22 points, and university level (including tertiary school) ≤ 23 points [11]. Postoperative follow-up visits were conducted in the outpatient clinic or by telephone, mainly to determine the survival status of patients.

The study was conducted in accordance with the Declaration of Helsinki and was approved by our institutional ethics committee. Informed consent was not required because the study was retrospective and anonymous.

Data collection

We collected data on the patients' demographic characteristics, comorbidities, preoperative test results, and surgical characteristics. Demographic characteristics included age, sex, region of residence, tobacco use, alcohol use, and BMI; comorbidities, including hypertension, diabetes mellitus, coronary heart disease, stroke, dementia, COPD, and pneumonia; preoperative investigations, including preoperative hemoglobin, albumin, and deep vein thrombosis; and surgical characteristics, including fracture type, injury-to-surgery time, ASA score, anesthesia modality, duration of surgery, intraoperative blood loss, and blood transfusion.

Statistical analysis

Patients were categorized into death and survival groups based on their 1-year survival status. Continuous

variables were grouped using the values given in previous studies or the median as the cutoff value, and count variables were expressed as frequencies (percentages). The Kaplan–Meier method was used to calculate the postoperative mortality rate, and comparisons between the death and survival groups were made using the log-rank test to determine the relationship between each factor and the 1-year postoperative mortality rate. Significant variables in the univariate analysis were entered into the Cox proportional hazards model for multivariate analysis to explore independent risk factors for 1-year postoperative mortality. To further investigate the effects of hypoproteinemia and being underweight on 1-year postoperative mortality in patients of different sexes, we performed subgroup analyses of male and female patients using the Kaplan–Meier method and log-rank test, respectively. Meanwhile, to further investigate the effects of age, injury-to-surgery time, and blood transfusion volume on 1-year postoperative mortality, we conducted subgroup analyses stratified by age ranges, injury-to-surgery intervals, and blood transfusion volumes using the Kaplan-Meier method and the log-rank test. P-values <0.05 were considered statistically significant. All statistical data were analyzed using SPSS 26.0 software (SPSS Inc., IBM, Chicago, IL, USA).

Results

Baseline characteristics

From January 2015 to December 2022, 875 patients with intertrochanteric fractures were admitted to our institution. After screening, 622 cases (406 women and 216 men) were ultimately included in this study (Fig. 1), of which 95 patients died within 1 year after surgery and no intraoperative deaths were recorded. The age of patients ranged from 65 to 100 years, with an average age of 79.00±7.39 years. Among the included cases, 169 cases were type A, 342 cases were type B, and 111 cases were type C. Preoperative comorbidities mainly included hypertension in 254 cases (40.84%), diabetes mellitus in 111 cases (17.85%), coronary heart disease in 180 cases (28.94%), stroke in 138 cases (22.19%), dementia in 76 cases (12.22%), COPD in 38 cases (6.11%), and pneumonia in 86 cases (13.83%). Three or more comorbidities were present in 121 patients (19.45%). Intravertebral anesthesia was used in 302 patients (48.55%), and general anesthesia was used in 320 patients (51.45%). The average length of hospitalization was 15.31±8.67 days.

Postoperative mortality and risk factors

The postoperative mortality rates of elderly patients with fragile intertrochanteric fractures at 1, 3, and 6 months, and 1 year were 3.86% (24 cases), 7.23% (45 cases), 10.13% (63 cases), and 15.27% (95 cases), respectively. Univariate analysis showed that advanced age, male sex, tobacco use, BMI <18.5, coronary heart disease, stroke, dementia, pneumonia, number of comorbidities ≥ 3, hypoproteinemia and injury-to-surgery time ≤ 2 days were associated with mortality at 1-year follow-up ($P<0.1$, Table 1). Multivariate analysis revealed that advanced age (2.047-fold increase, 95% CI: 1.341–3.125), male sex (1.514-fold increase, 95% CI: 1.005–2.281), dementia (2.374-fold increase, 95% CI: 1.490–3.783), number of comorbidities ≥ 3 (2.119-fold increase, 95% CI: 1.357–3.309), hypoalbuminemia (1.615-fold increase, 95% CI: 1.058–2.466), and being underweight (1.686-fold increase, 95% CI: 1.034–2.749) were independent risk factors for 1-year postoperative mortality in elderly patients with fragile intertrochanteric fractures ($P<0.05$, Table 2).

Subgroup analysis

Subgroup analysis showed that being underweight was associated with 1-year postoperative mortality only in male patients but not in female patients (Fig. 2a and b), whereas hypoproteinemia was associated with 1-year postoperative mortality in both male and female patients (Fig. 3a and b).

Although no statistically significant difference was present in the postoperative 1-year survival rates among the three groups of injury-to-surgery time ≤ 2 days, > 2 days and ≤ 5 days, and >5 days, in a two-by-two comparison between the groups, the injury-to-surgery time ≤ 2 days group had a higher postoperative 1-year survival rate than the >2 days and ≤ 5 days and >5 days groups (Fig. 4).

The postoperative 1-year survival rates of patients in the age ≥ 65 years and <70 years group, age ≥ 70 years and <80 years group, and age ≥ 80 years group gradually decreased with statistical differences. In the two-by-two comparisons between groups, the postoperative 1-year survival rates of patients in the age ≥ 65 and <70 years group and age ≥ 70 and <80 years group were better than those in the age ≥ 80 years group (Fig. 5).

There was no significant difference in postoperative 1-year survival among the no-transfusion group, the blood transfusion volume ≤ 2u group, the blood transfusion volume >2u and ≤ 4u group, and the blood transfusion volume >4u group. The same remained true for two-by-two comparisons between groups. Although the 1-year postoperative survival rate was lower in patients with blood transfusion volume >4u, there was no statistical difference (Fig. 6).

Discussion

In this study, 95 (15.3%) of 622 elderly patients with intertrochanteric fractures who received PFNA died within 1 year of surgery. Multivariate analysis showed that advanced age, male sex, dementia, number of comorbidities ≥ 3, hypoalbuminemia, and being underweight were

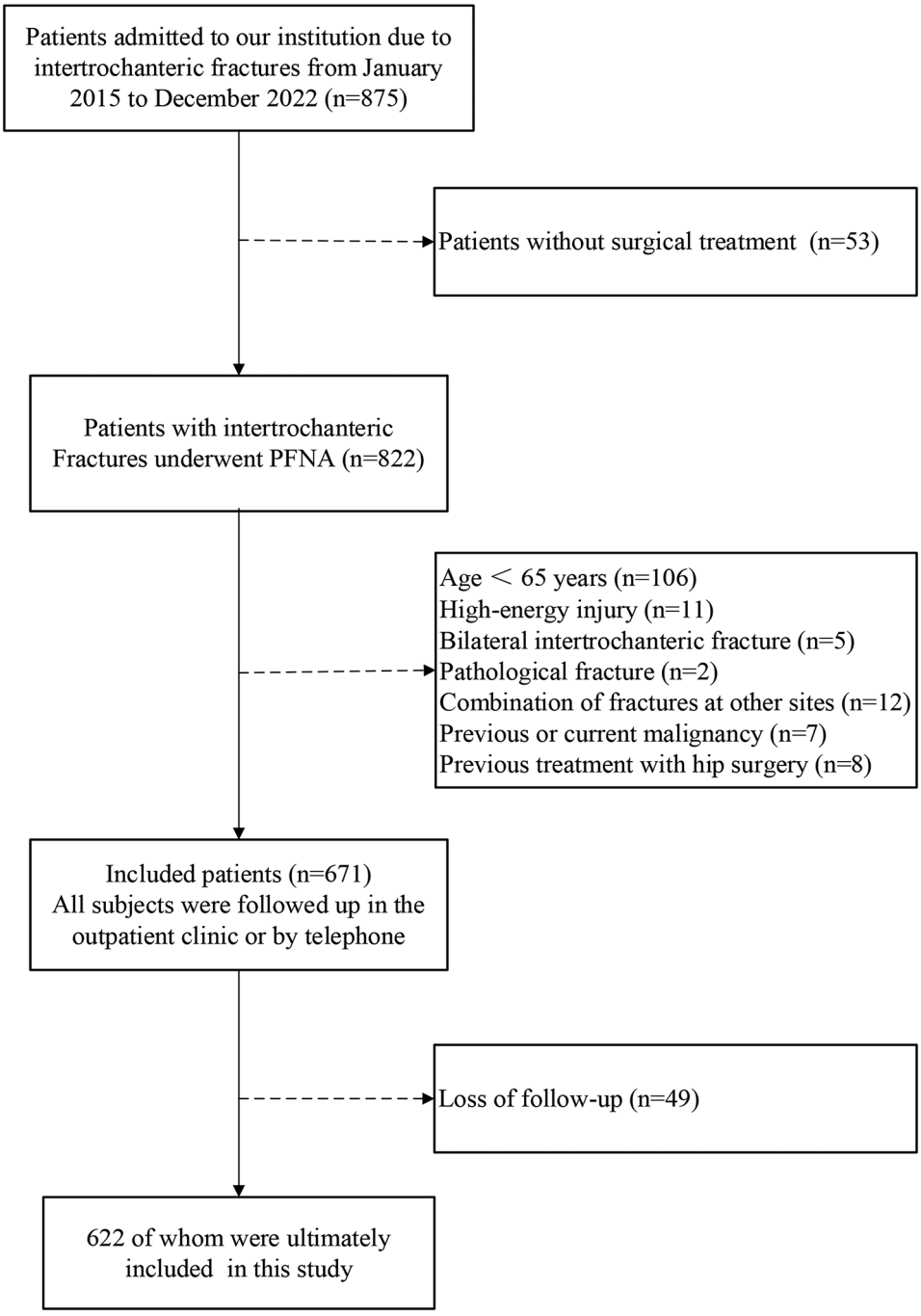

Fig. 1 Flowchart of recruited patients according to the inclusion and exclusion criteria

independent risk factors for 1-year postoperative mortality. These findings help us screen high-risk patients for intertrochanteric fractures preoperatively to assess anesthetic and surgical risks, and thus to predict whether these individuals will benefit from the procedure.

Age

The effect of age on postoperative survival in patients with hip fracture is controversial. Although different clinical studies have selected slightly different age cutoffs, most of them tend to favor a worse survival prognosis for advanced-age hip fracture patients than for non-advanced-age patients [12–15]. However, some scholars believe that there is no direct correlation between age and postoperative mortality in hip fracture patients [16, 17]. With the increase in age, the elderly have a higher postoperative mortality rate due to the aging of systemic organs, deterioration of

Table 1 Univariate analysis of factors associated with 1-year mortality after PFNA of intertrochanteric fractures

Characteristics (assignment)	Overall	Death group (95)	Survival group (527)	χ^2	*P*-value
Age (y)				12.271	< 0.001
< 80 (0)	331 (53.22%)	35 (36.84%)	296 (56.17%)		
≥ 80 (1)	291 (46.78%)	60 (63.16%)	231 (43.83%)		
Sex				4.507	0.034
Female (0)	406 (65.27%)	53 (55.79%)	353 (66.98%)		
Male (1)	216 (34.73%)	42 (44.21%)	174 (33.02%)		
Region of residence				1.763	0.184
Urban (0)	398 (63.99%)	55 (57.89%)	343 (65.09%)		
Rural (1)	224 (36.01%)	40 (42.11%)	184 (34.91%)		
Tobacco use				3.275	0.070
Yes (1)	77 (12.38%)	17 (17.89%)	60 (11.39%)		
No (0)	545 (87.62%)	78 (82.11%)	467 (88.61%)		
Alcohol use				0.024	0.876
Yes (1)	50 (8.04%)	8 (8.42%)	42 (7.97%)		
No (0)	572 (91.96%)	87 (91.58%)	485 (92.03%)		
BMI				6.702	0.010
< 18.5 (0)	91 (14.63%)	22 (23.16%)	69 (13.09%)		
≥ 18.5 (1)	531 (85.37%)	73 (76.84%)	458 (86.91%)		
Hypertension				0.182	0.670
Yes (1)	254 (40.84%)	37 (38.95%)	217 (41.18%)		
No (0)	368 (59.16%)	58 (61.05%)	310 (58.82%)		
Diabetes mellitus				0.361	0.548
Yes (1)	111 (17.85%)	19 (20%)	92 (17.46%)		
No (0)	511 (82.15%)	76 (80%)	435 (82.54%)		
Coronary heart disease				4.934	0.026
Yes (1)	180 (28.94%)	36 (37.89%)	144 (27.32%)		
No (0)	442 (71.06%)	59 (62.11%)	383 (72.68%)		
Stroke				3.336	0.068
Yes (1)	138 (22.19%)	28 (29.47%)	110 (20.87%)		
No (0)	484 (77.81%)	67 (70.53%)	417 (79.13%)		
Dementia				26.017	< 0.001
Yes (1)	76 (12.22%)	26 (27.37%)	50 (9.49%)		
No (0)	546 (87.78%)	69 (72.63%)	477 (90.51%)		
COPD				2.376	0.123
Yes (1)	38 (6.11%)	9 (9.47%)	29 (5.50%)		
No (0)	584 (93.89%)	86 (90.53%)	498 (94.50%)		
Pneumonia				5.339	0.021
Yes (1)	86 (13.83%)	20 (21.05%)	66 (12.52%)		
No (0)	536 (86.17%)	75 (78.95%)	461 (87.48%)		
Number of comorbidities				11.181	0.001
< 3 (0)	501 (80.55%)	65 (68.42%)	436 (82.73%)		
≥ 3 (1)	121 (19.45%)	30 (31.58%)	91 (17.27%)		
Anemia				0.409	0.522
Yes (1)	421 (67.68%)	67 (70.53%)	354 (67.17%)		
No (0)	201 (32.32%)	28 (29.47%)	173 (32.83%)		
Preoperative ALB (g/L)				13.602	< 0.001
< 35 (1)	259 (41.64%)	56 (58.95%)	203 (38.52%)		
≥ 35 (0)	363 (58.36%)	39 (41.05%)	324 (61.48%)		
Deep venous thrombosis				0.901	0.342
Yes (1)	71 (11.41%)	8 (8.42%)	63 (11.95%)		
No (0)	551 (88.59%)	87 (91.58%)	464 (88.05%)		
AO classification				1.271	0.530
A1 (0)	169 (27.17%)	30 (31.58%)	139 (26.38%)		

Table 1 (continued)

Characteristics (assignment)	Overall	Death group (95)	Survival group (527)	χ^2	*P*-value
A2 (1)	342 (54.98%)	47 (49.47%)	295 (55.98%)		
A3 (2)	111 (17.85%)	18 (18.95%)	93 (17.65%)		
Injury-to-surgery time (d)				4.344	0.037
≤ 2 (0)	64 (10.29%)	4 (4.21%)	60 (11.39%)		
> 2(1)	558 (89.71%)	91 (95.79%)	467 (88.61%)		
ASA score				1.990	0.158
1, 2 (0)	230 (36.98%)	29 (30.53%)	201 (38.14%)		
3, 4 (0)	392 (63.02%)	66 (69.47%)	326 (61.86%)		
Anesthesia modality				1.263	0.261
Intravertebral anesthesia (0)	302 (48.55%)	51 (53.68%)	251 (47.63%)		
General anesthesia (1)	320 (51.45%)	44 (46.32%)	276 (52.37%)		
Duration of surgery (min)				0.009	0.924
≤ 70 (0)	369 (59.32%)	57 (60%)	312 (59.20%)		
> 70 (1)	253 (40.68%)	38 (40%)	215 (40.80%)		
Intraoperative blood loss (mL)				0.984	0.321
≤ 90 (0)	241 (38.75%)	41 (43.16%)	200 (37.95%)		
> 90 (1)	381 (61.25%)	54 (56.84%)	327 (62.05%)		
Blood transfusion				2.023	0.155
Yes (1)	197 (31.67%)	36 (37.89%)	161 (30.55%)		
No (0)	425 (68.33%)	59 (62.11%)	366 (69.45%)		

Abbreviations BMI, body mass index; COPD, chronic obstructive pulmonary disease; ALB, serum albumin; AO: Arbeitsgemeinschaftfür Osteosynthesefragen; ASA: American Society of Anesthesiologists

Table 2 Multivariate analysis of factors associated with 1-year mortality after PFNA of intertrochanteric fractures

Characteristics	B	Standard error	Wald	Odds ratio	95% Confidence interval		*P*-value
					Lower	Upper	
Age (y) ≥ 80	0.716	0.216	11.011	2.047	1.341	3.125	0.001
Sex (Male)	0.415	0.209	3.935	1.514	1.005	2.281	0.047
Dementia	0.865	0.238	13.228	2.374	1.490	3.783	< 0.001
No. of comorbidities ≥ 3	0.751	0.227	10.918	2.119	1.357	3.309	0.001
Hypoproteinemia	0.480	0.216	4.939	1.615	1.058	2.466	0.026
BMI < 18.5	0.523	0.249	4.390	1.686	1.034	2.749	0.036

Abbreviations BMI, body mass index

cardiopulmonary reserve, low immunity, and poor stress capacity following trauma, anesthesia, and surgery [15]. Our study similarly showed that the 1-year postoperative mortality rate was significantly higher in patients aged ≥ 80 years than in those aged < 80 years. Multivariate analysis confirmed advanced age as an independent risk factor for 1-year postoperative mortality. Similarly, subgroup analyses showed an increasing trend in 1-year postoperative mortality in patients with intertrochanteric fractures with increasing age.

Sex

In the present study, female patients constituted 65.3% (406 patients) of the study population, indicating that elderly women are more prone to fragility intertrochanteric fractures than men. The mean age at which fragility fractures occurred in elderly men was 77.6 ± 7.3 years compared with 79.8 ± 7.4 years in women ($P < 0.001$). Among the patients who died, the mean age was 79.8 ± 6.7 years for men and 83.0 ± 7.2 years for women ($P = 0.026$). Multivariate analysis showed that male sex was an independent risk factor for 1-year postoperative mortality, which is similar to previous findings [13, 15, 18]. Some studies have shown that mortality rates at 1, 3, and 12 months after surgery are higher in elderly male hip fracture patients than in elderly female patients [14]. This suggests that although the incidence and age at onset of intertrochanteric fractures in elderly women are greater than those in elderly men, the prognosis is better than that in male patients. Some scholars believe that this is related to the fact that male patients have poor living habits and are often combined with hypertension, coronary heart disease, COPD, and other underlying diseases [19]. In our subgroup analysis, a strong correlation between underweight and 1-year postoperative mortality was observed only in male patients. We speculate that the relatively high postoperative mortality rate in male

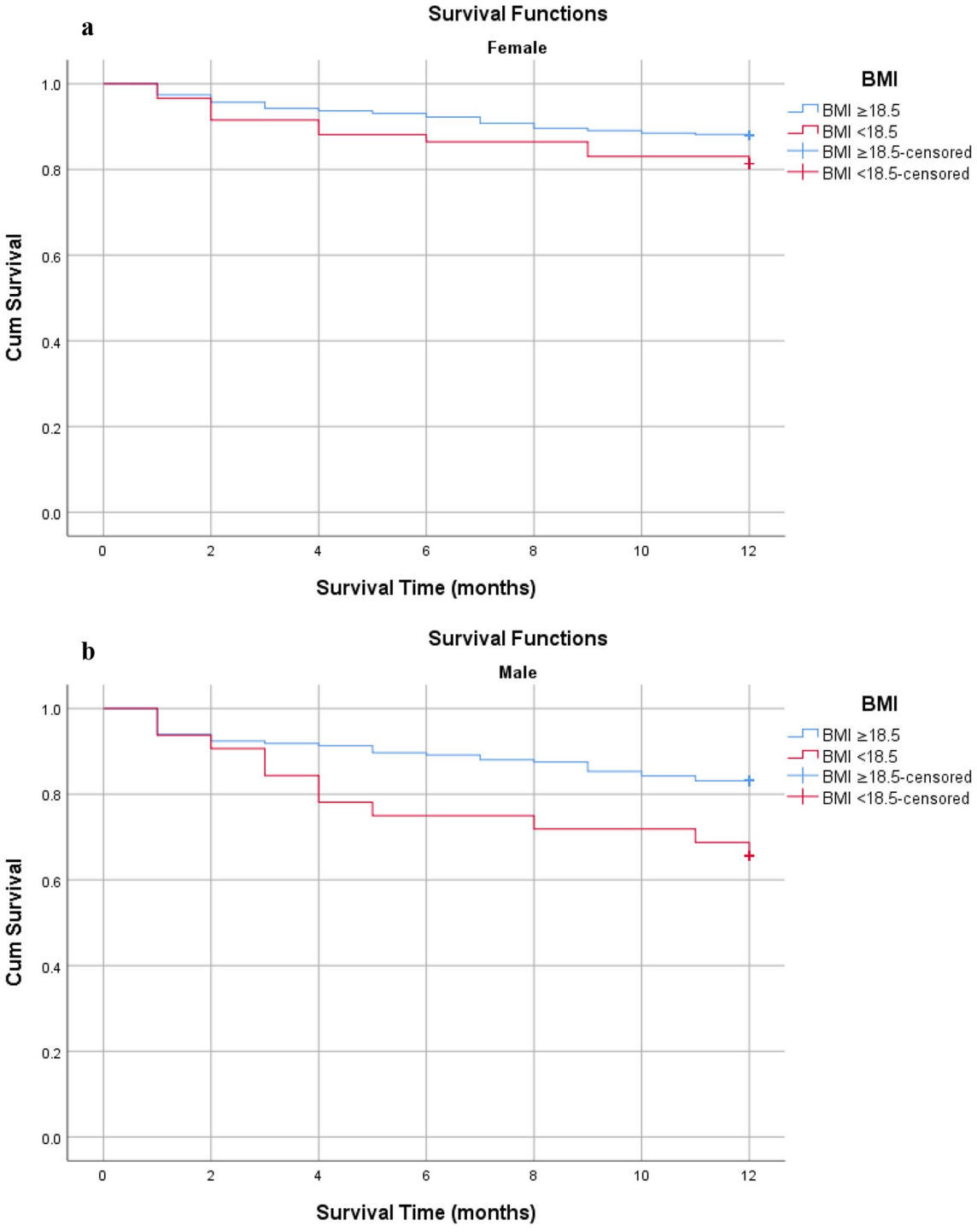

Fig. 2 The Kaplan–Meier curve for the cumulative incidence of subsequent fragile intertrochanteric fractures after surgery based on body mass index (BMI) group (< 18.5 or ≥ 18.5). **a** Female patients ($\chi^2 = 1.942$, $P = 0.163$). **b** Male patients ($\chi^2 = 5.571$, $P = 0.018$)

patients may be somehow correlated with a low BMI, although the specific cause requires further exploration.

Dementia

For patients with hip fracture, cognitive impairment is often a factor that is easily overlooked by medical staff, as it does not appear to be a factor that leads to serious consequences; however, cognitive impairment has an adverse effect on the prognosis of patients after hip fracture surgery [20]. A systematic review and meta-analysis showed that the 1-month, 3-month, and 1-year mortality rates for hip fracture patients with and without dementia were

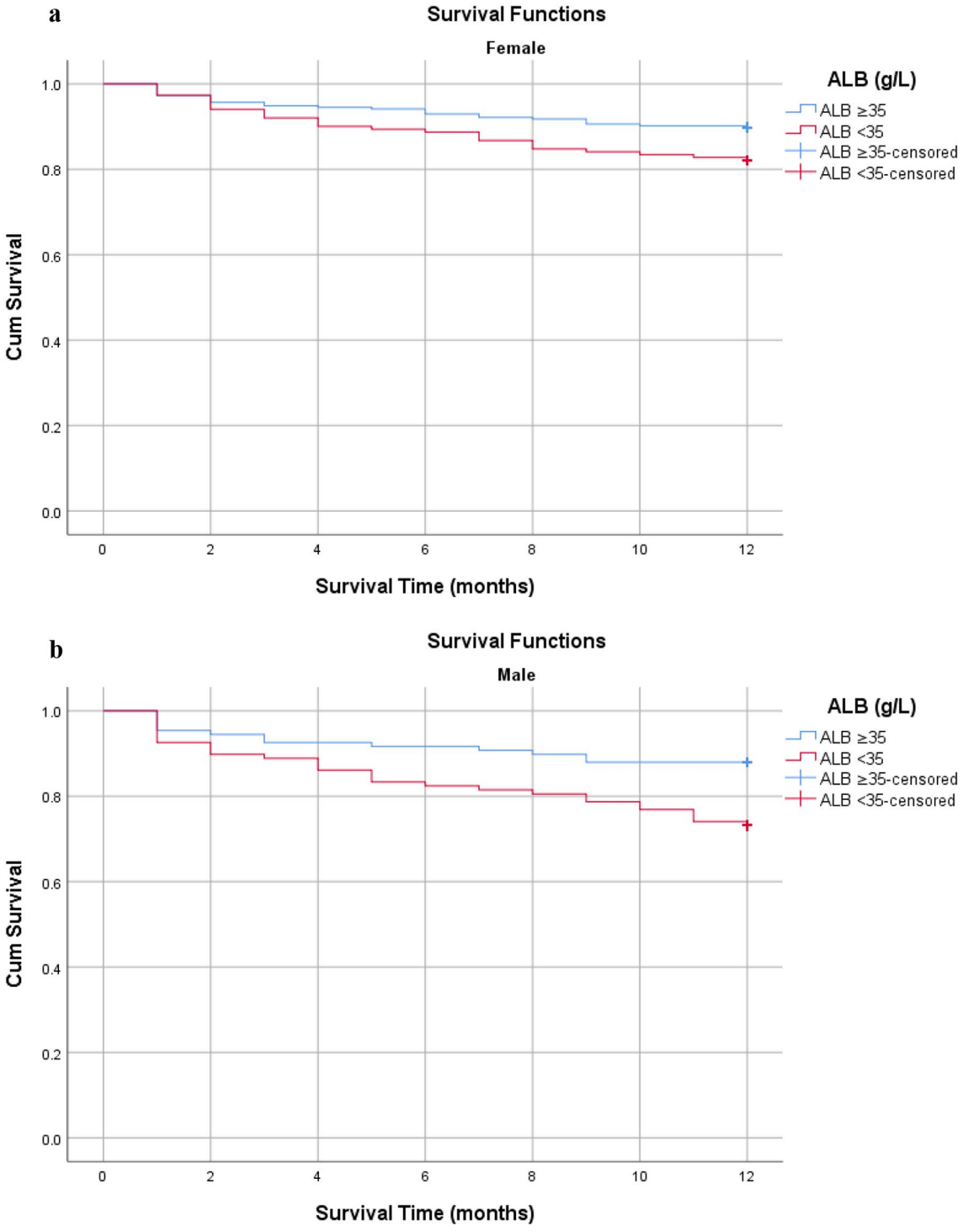

Fig. 3 The Kaplan–Meier curve for the cumulative incidence of subsequent fragile intertrochanteric fractures after surgery based on serum albumin (ALB) group (< 35 g/L or ≥ 35 g/L). **a** Female patients ($\chi^2 = 4.870$, $P = 0.027$). **b** Male patients ($\chi^2 = 7.249$, $P = 0.007$)

7.40% vs. 5.17%, 9.43% vs. 6.64%, and 34.78% vs. 20.76%, respectively [21]. Similarly, a large cohort study that included 6626 cases showed that hip fracture patients with dementia had a 1-month and 1-year postoperative risk of death that was 1.73 and 1.45 times higher than that of patients without dementia, respectively [14]. Lower cognitive function has a negative impact on physical activity and recovery of physical function after surgery in elderly hip fracture patients [22, 23]. Whether due to the dementia itself or the dementia-induced delirium, these

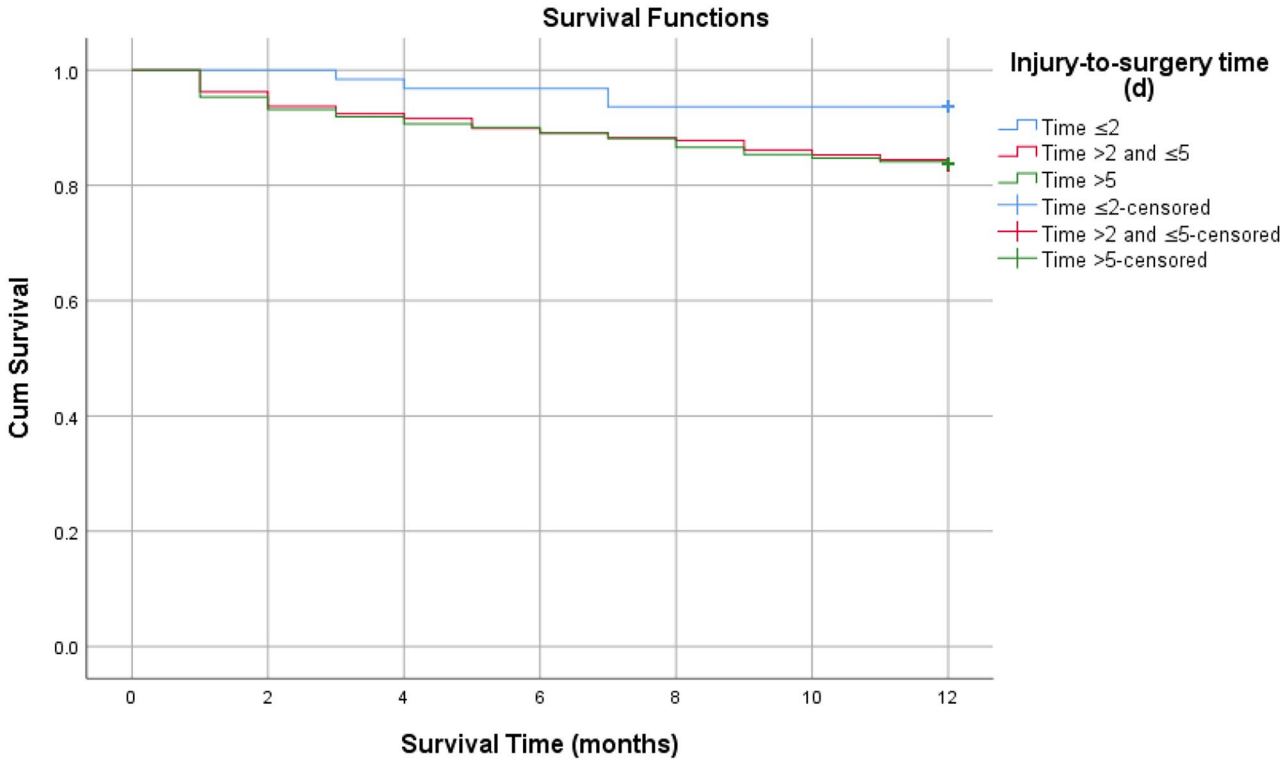

Fig. 4 The Kaplan–Meier curve for the cumulative incidence of subsequent fragile intertrochanteric fractures after surgery based on injury-to-surgery time group (≤ 2 days, > 2 days and ≤ 5 days, > 5 days). (1) Comparison of three groups, $\chi^2 = 4.179$, $P = 0.124$. (2) Two-by-two comparisons between groups. Time ≤ 2 days vs. Time > 2 days and ≤ 5 days, $\chi^2 = 4.002$, $P = 0.045$. Time ≤ 2 days vs. Time > 5 days, $\chi^2 = 4.007$, $P = 0.045$. Time > 2 days and ≤ 5 days vs. Time > 5 days, $\chi^2 = 0.001$, $P = 0.975$

cognitively impaired patients are often unable to follow their physician's instructions for routine and necessary post-surgical functional recovery training [24]. Prolonged postoperative bed rest will not only aggravate muscle atrophy in the lower limbs of patients with hip fracture, leading to a decrease in muscle strength [25], but also lead to more serious postoperative complications, such as infections of the surgical site, lung, and urinary tract [26]. Special nursing interventions are necessary for hip fracture patients with dementia [14, 27].

Comorbidity

In our study, none of the preoperative comorbidities (e.g., hypertension, coronary heart disease, stroke, COPD, pneumonia) were independent risk factors for 1-year postoperative mortality, except for dementia. However, patients with ≥3 comorbidities had a 2.119-fold increased risk of death. A large data study showed that elderly hip fracture patients with ≥2 comorbidities had a 1.53- and 1.72-fold increased risk of death at 3 months and 1 year after surgery, respectively [14]. It has been shown that the main causes of perioperative death in elderly patients with intertrochanteric fractures are cardiovascular and cerebrovascular accidents, pulmonary infections, and multiorgan failure, and that perioperative mortality is closely related to the presence of chronic diseases in major organs (heart, brain, and lung) [28]. The results of an 11-year long-term follow-up study revealed that postoperative mortality in hip fracture patients is associated with hypertension, diabetes, and stroke [29]. A Danish study showed that comorbidity was an important risk factor for infection within 1 year of hip fracture surgery [30]. This highlights not only the importance of monitoring the respiratory and cardiocerebral vascular systems in various aspects, especially for patients with combined chronic diseases of major organs, but also the need to work with relevant internal medicine departments to adequately assess the patient's tolerance of anesthesia and surgery and to actively treat the primary disease to reduce the incidence of perioperative complications and thus improve the patient's prognosis.

Hypoalbuminemia

As one of the most accepted and widely used markers of nutritional status, a serum albumin concentration of <3.5 g/dL is considered to indicate malnutrition, and up to 45.9% of hip fracture patients have combined hypoalbuminemia [31]. In our study, 259 patients (41.6%) with intertrochanteric fractures had combined hypoproteinemia, and the postoperative mortality rate of patients

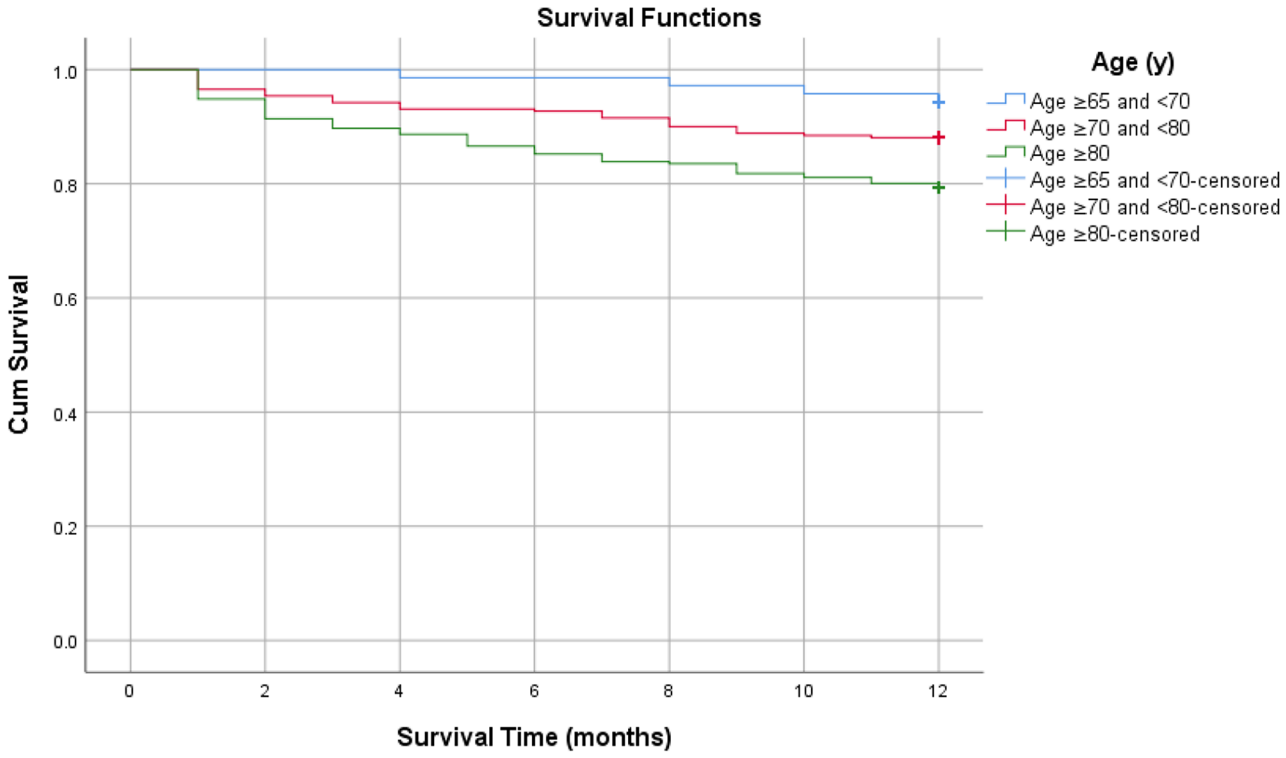

Fig. 5 The Kaplan–Meier curve for the cumulative incidence of subsequent fragile intertrochanteric fractures after surgery based on age group (≥ 65 years and < 70 years, ≥ 70 years and < 80 years, ≥ 80 years). (1) Comparison of three groups, χ^2 =13.896, *P* = 0.001. (2) Two-by-two comparisons between groups. Age ≥ 65 years and < 70 years vs. Age ≥ 70 years and < 80 years, χ^2 =2.405, *P* = 0.121. Age ≥ 65 years and < 70 years vs. Age ≥ 80 years, χ^2 = 8.644, *P* = 0.003 Age ≥ 70 years and < 80 years vs. Age ≥ 80 years, χ^2 = 7.503, *P* = 0.006

with combined hypoproteinemia was significantly higher than that of healthy patients of both sexes. Previous studies have found that hypoproteinemia was strongly associated with an increased risk of death at 1 month and 1 year after hip fracture [32]. Several studies have demonstrated that hypoproteinemia is an independent risk factor for short- [17] and long-term mortality [15, 16] after hip fracture. Another showed that every 1 g/dL increase in preoperative serum albumin concentration in hip fracture patients was associated with a 0.59-fold reduction in the risk of death [31]. Previous studies demonstrated a strong correlation between preoperative hypoalbuminemia and the development of postoperative pneumonia in elderly hip fractures [33, 34]. Moreover, the 30-day all-cause mortality rate was significantly higher in patients with postoperative pneumonia (27.1%) than in those without postoperative pneumonia (1.1%) [35]. Oral supplementation with amino acids can effectively improve perioperative hypoproteinemia. A randomized controlled trial showed that oral supplementation with essential amino acids in hip fracture patients was effective in promoting improvement in more than two-thirds of cases of hypoproteinemia and more than one-third of cases of anemia [36].

BMI

The positive relationship between high BMI and survival in elderly patients or those with chronic disease is known as the "obesity paradox," which also applies to patients with hip fracture [37]. Overweight or obese hip fracture patients have a higher survival rate than patients of a healthy weight, whereas underweight patients have a worse survival rate than patients of a healthy weight [37–39]. The mechanism of the "obesity paradox" is currently unclear. One hypothesis is that after hip fracture, the body experiences a series of stress reactions, metabolic disorders, and a prolonged catabolic state [40], and excess body fat in overweight or obese patients acts as a metabolic reserve [37]. Thus, overweight or obese patients may be better able to tolerate the intra- and extra-organic irritations that accompany traumatic injury and critical illnesses [41]. This suggests that the perioperative management of patients with intertrochanteric or hip fractures should focus on malnourished and underweight patients rather than overweight or obese patients [37]. Oral nutritional supplements (ONS) and enteral nutrition administered during the perioperative period can markedly improve the patient's overall nutritional status, reduce postoperative complications, shorten hospital stays, and enhance the quality of life for elderly patients suffering from hip fractures [42]. If ONS and

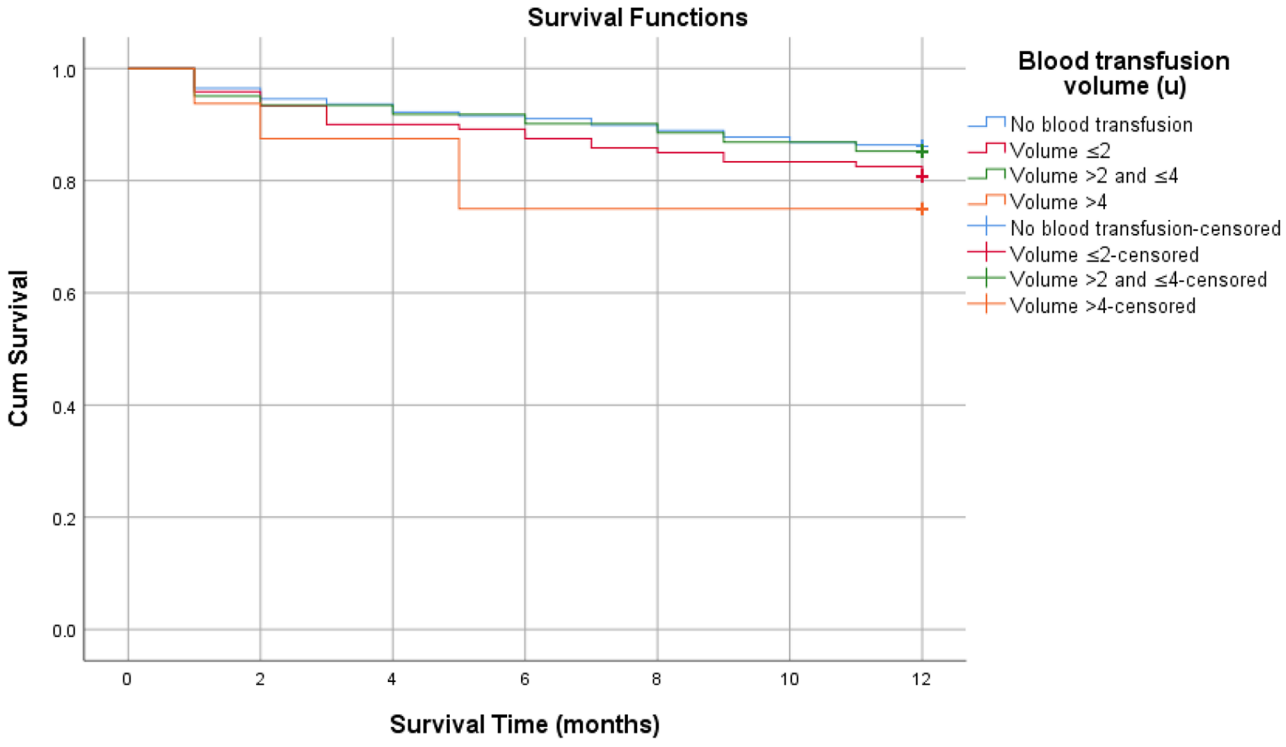

Fig. 6 The Kaplan–Meier curve for the cumulative incidence of subsequent fragile intertrochanteric fractures after surgery based on blood transfusion volume group (no blood transfusion, volume ≤ 2 u, volume > 2 u and ≤ 4 u, volume > 4 u). (1) Comparison of three groups, χ^2 =3.393, *P* = 0.335. (2) Two-by-two comparisons between groups. No blood transfusion vs. Volume ≤ 2 u, χ^2 =2.034, *P* = 0.154. No blood transfusion vs. Volume > 2 u and ≤ 4 u, χ^2 =0.034, *P* = 0.854. No blood transfusion vs. Volume > 4 u, χ^2 =1.771, *P* = 0.183. Volume ≤ 2 u vs. Volume > 2 u and ≤ 4 u, χ^2 =0.515, *P* = 0.473. Volume ≤ 2 u vs. Volume > 4 u, χ^2 =0.382, *P* = 0.537. Volume > 2 u and ≤ 4 u vs. Volume > 4 u, χ^2 =1.025, *P* = 0.311

enteral nutrition do not fulfill the patient's needs, concurrent initiation of partial parenteral nutrition is advisable [43].

Timing of surgery

For hip fractures in elderly patients, the prevailing view is to recommend early surgical treatment, preferably within 48 h of admission [43]. A systematic review and meta-analysis that included 191,873 patients with hip fractures showed that early surgical treatment after admission was an effective measure to reduce postoperative mortality and complications [44]. In our study, although an injury-to-surgery time of more than 2 days was not an independent risk factor for 1-year postoperative mortality in patients with intertrochanteric fracture, subgroup analyses showed that patients with an injury-to-surgery time ≤ 2 days had a significantly better prognosis than those with a time of more than 2 days. Unfortunately, injury-to-surgery time ≤ 2 days accounted for only 10.29% (64 cases) of the total number of patients in our study. This phenomenon can be attributed to the fact that a majority of the patients included in our study were referred from lower-tier hospitals, coupled with their advanced age and living in rural areas, where there is a notable lack of awareness regarding hip fractures, leading to delayed presentation for medical care. Certain patients remain bedridden at home for 1–2 days or even longer before seeking medical attention, as their hip pain persists without relief. However, some scholars have drawn the opposite conclusion. Vidal et al. demonstrated that the interval between admission and surgery was not associated with 1-year postoperative mortality [45], while Kim et al. indicated that delayed surgical intervention does not affect the incidence of postoperative complications related to hip fractures [46]. In light of this, it is advisable to implement an individualized treatment protocol in which early surgery is recommended for patients with few comorbidities [47]. Conversely, for older patients with multiple underlying conditions requiring various medical interventions, early surgery does not improve prognosis; therefore, aggressive management of the underlying diseases should be prioritized [47].

Blood transfusion

Anemia is prevalent among patients with hip fractures [48]. Moreover, it is a modifiable factor, and the indication for blood transfusion in patients with asymptomatic postoperative hip fractures is a hemoglobin level of less than 8 g/dL [43]. A previous study has concluded that erythrocyte blood transfusions do not directly increase

postoperative mortality in patients with hip fractures [49]. However, Jang et al. have demonstrated that blood transfusion adversely affects 1-year postoperative survival in patients with hip fractures [48]. Our study revealed that blood transfusion and diverse transfusion volumes did not have a direct effect on 1-year postoperative mortality in elderly patients with intertrochanteric fractures. Although we observed a trend toward increased mortality when transfusions were >4u, it was not statistically significant. Further studies are needed to confirm whether massive blood transfusions adversely affect patients' postoperative survival.

Limitations

Only elderly patients with fragile intertrochanteric fractures who underwent PFNA were included in this study to minimize the heterogeneity associated with different fracture sites and surgical approaches. However, there are still some limitations. First, this was a single-center, retrospective study, which may also lead to selection bias, and multicenter prospective studies are still needed to further confirm the findings. Second, we did not trace and analyze the specific cause of death of the deceased patient. Third, although we included and analyzed many variables, some risk factors affecting mortality may have been overlooked.

Conclusion

Postoperative mortality in elderly patients with fragile intertrochanteric fractures is the result of the interaction of multiple factors. Therefore, priority care should be given to patients with chronic diseases of major organs and poor nutritional status, especially older male patients. In underweight patients and those with hypoproteinemia, perioperative nutritional status should be improved in a timely manner, thereby reducing postoperative mortality. In patients with fewer comorbidities, surgery should be initiated as soon as possible.

Supplementary Information

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Supplementary Material 1

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Author contributions

H.W. and X.H. designed the study. X.H. and F.C. collected and collated the data from the medical records. X.H. and L.H. performed the statistical analysis. L.H. and F.C. typed the fractures according to the AO classification. X.H., L.H. and F.C. drafted the manuscript. B.L., F.S. and D.J. conducted the follow-up. All authors reviewed and approved the final manuscript.

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Data availability

All datasets analyzed during this study are available from the corresponding author upon reasonable request.

Declarations

Ethical approval

Study approval was obtained from the Institutional Review Board (No. 2023-12-C036). Because the study was retrospective and anonymous, informed consent was not required.

Competing interests

The authors declare no competing interests.

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References

1. Sing CW, Lin TC, Bartholomew S, et al. Global epidemiology of hip fractures: secular trends in incidence rate, post-fracture treatment, and all-cause mortality. J Bone Min Res. 2023;38(8):1064–75.
2. Hopkins RB, Pullenayegum E, Goeree R, Adachi JD, Papaioannou A, Leslie WD, Tarride JE, Thabane L. Estimation of the lifetime risk of hip fracture for women and men in Canada. Osteoporos Int. 2012;23(3):921–7.
3. Fox KM, Cummings SR, Williams E, Stone K, Study Osteoporotic F. Femoral neck and intertrochanteric fractures have different risk factors: a prospective study. Osteoporos Int. 2000;11(12):1018–23.
4. Maffulli N, Aicale R. Proximal femoral fractures in the Elderly: a few things to know, and some to forget. Med (Kaunas). 2022;58(10):1314.
5. Frisch NB, Wessell N, Charters M, Greenstein A, Shaw J, Peterson EJJ. Hip fracture mortality: differences between intertrochanteric and femoral neck fractures. J Surg Orthop Adv. 2018;27(1):64–71.
6. Cui ZY, Feng H, Meng XY, Zhuang SY, Liu ZR, Ye KF, Sun C, Xing Y, Zhou F, Tian Y. Age-specific 1-year mortality rates after hip fracture based on the populations in mainland China between the years 2000 and 2018: a systematic analysis. Arch Osteoporos. 2019;25(1):55.
7. Haentjens P, Autier P, Barette M, Venken K, Vanderschueren D, Boonen S, Bone HFSGJ. Survival and functional outcome according to hip fracture type: a one-year prospective cohort study in elderly women with an intertrochanteric or femoral neck fracture. Bone. 2007;41(6):958–64.
8. Vestergaard P, Rejnmark L, Mosekilde LJJAGS. Has mortality after a hip fracture increased? J Am Geriatr Soc. 2007;55(11):1720–6.
9. Marsillo E, Pintore A, Asparago G, Oliva F, Maffulli N. Cephalomedullary nailing for reverse oblique intertrochanteric fractures 31A3 (AO/OTA). Orthop Rev (Pavia). 2022;14(6):38560.
10. Gargano G, Poeta N, Oliva F, Migliorini F, Maffulli N. Zimmer Natural Nail and ELOS nails in pertrochanteric fractures. J Orthop Surg Res. 2021;16(1):509.
11. Folstein MF, Folstein SE. McHugh PRJJopr. Mini-mental state: a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975;12(3):189–98.
12. Mariconda M, Costa GG, Cerbasi S, Recano P, Aitanti E, Gambacorta M, Misasi M. The determinants of mortality and morbidity during the year following fracture of the hip: a prospective study. Bone Joint J. 2015;97–B(3):383–90.
13. Wang PW, Yao XD, Zhuang HF, Li YZ, Xu H, Lin JK, Liu WG. Mortality and related risk factors of fragile hip fracture. Orthop Surg. 2022;14(10):2462–9.

14. Chiu HC, Chen CM, Su TY, Chen CH, Hsieh HM, Hsieh CP, Shen DL. Dementia predicted one-year mortality for patients with first hip fracture: a population-based study. Bone Joint J. 2018;100–B(9):1220–6.
15. Jianwen Z, Xiaowei W, Tianshen S, Zhi L, jianzheng Z. Mortality and risk factors for death in elderly hip fracture patients with in 1 year after surgery. J Practical Orthop. 2020;26:399–403.
16. Zhang Y, Huang LL, Liu Y, Chen Q, Li X, Hu J. Prediction of mortality at one year after surgery for pertrochanteric fracture in the elderly via a bayesian belief network. Injury. 2020;51(2):407–13.
17. Chen X, Zhang J, Lin Y, Liu Z, Sun T, Wang XJOI. Risk factors for postoperative mortality at 30 days in elderly Chinese patients with hip fractures. Osteoporos Int. 2022;33(5):1109–16.
18. Bilsel K, Erdil M, Gulabi D, Elmadag M, Cengiz O, Sen CJEJOS. Factors affecting mortality after hip fracture surgery: a retrospective analysis of 578 patients. Eur J Orthop Surg Traumatol. 2013;23(8):895–900.
19. Lobo E, Marcos G, Santabárbara J, Lobo-Escolar L, Salvador-Rosés H, De la Cámara C, Lopez-Anton R, Gracia-García P, Lobo-Escolar A, Workgrp Z. Gender differences in the association of cognitive impairment with the risk of hip fracture in the older population. Maturitas. 2018;109:39–44.
20. Mundi S, Chaudhry H, Bhandari M. Systematic review on the inclusion of patients with cognitive impairment in hip fracture trials: a missed opportunity? Can J Surg. 2014;57(4):E141–5.
21. Hou MZ, Zhang YJ, Chen AC, Liu T, Yang HL, Zhu XS, He F. The effects of dementia on the prognosis and mortality of hip fracture surgery: a systematic review and meta-analysis. Aging Clin Exp Res. 2021;33(12):3161–72.
22. Runde HA, Taraldsen K, Follestad T, Saltvedt I, Johnsen LG. The impact of cognitive function on physical activity, physical function and quality of life in older adults following a hip fracture. Age Ageing. 2023;52(4):afad061.
23. Kamimura T, Kobayashi Y, Tamaki S, Koinuma MJJAMDA. Impact of prefracture cognitive impairment and postoperative delirium on recovery after hip fracture surgery. J Am Med Dir Assoc. 2024;25(8):104961.
24. Talsnes O, Vinje T, Gjertsen JE, Dahl OE, Engesæter LB, Baste V, Pripp AH, Reikerås O. Perioperative mortality in hip fracture patients treated with cemented and uncemented hemiprosthesis: a register study of 11,210 patients. Int Orthop. 2013;37(6):1135–40.
25. Chen YP, Kuo YJ, Hung SW, Wen TW, Chien PC, Chiang MH, Maffulli N, Lin CY. Loss of skeletal muscle mass can be predicted by Sarcopenia and reflects poor functional recovery at one year after surgery for geriatric hip fractures. Injury. 2021;52(11):3446–52.
26. Tsuda Y, Yasunaga H, Horiguchi H, Ogawa S, Kawano H, Tanaka S. Association between dementia and postoperative complications after hip fracture surgery in the elderly: analysis of 87,654 patients using a national administrative database. Arch Orthop Trauma Surg. 2015;135(11):1511–7.
27. Morioka N, Moriwaki M, Tomio J, Kashiwagi M, Fushimi K, Ogata Y. Structure and process of dementia care and patient outcomes after hip surgery in elderly people with dementia: a retrospective observational study in Japan. Int J Nurs Stud. 2020;102:103470.
28. Zhao F, Wang X, Dou Y, Wang H, Zhang YJEJOS, Traumatology. Analysis of risk factors for perioperative mortality in elderly patients with intertrochanteric fracture. Eur J Orthop Surg Traumatol. 2019;29(1):59–63.
29. Choi HG, Lee YB, Rhyu SH, Kwon BC, Lee JK. Mortality and cause of death postoperatively in patients with a hip fracture: a national cohort longitudinal follow-up study. Bone Joint J. 2018;100–B(4):436–42.
30. Gadgaard NR, Varnum C, Nelissen R, Vandenbroucke-Grauls C, Sorensen HT, Pedersen AB. Comorbidity and risk of infection among patients with hip fracture: a Danish population-based cohort study. Osteoporos Int. 2023;34(10):1739–49.
31. Bohl DD, Shen MR, Hannon CP, Fillingham YA, Darrith B, Della Valle CJ. Serum albumin predicts survival and postoperative course following surgery for geriatric hip fracture. J Bone Joint Surg Am. 2017;99(24):2110–8.
32. Frandsen CF, Glassou EN, Stilling M, Hansen TB. Malnutrition, poor function and comorbidities predict mortality up to one year after hip fracture: a cohort study of 2800 patients. Eur Geriatr Med. 2022;13(2):433–43.
33. Tian YX, Zhu YB, Zhang KX, Tian M, Qin SH, Li XT. Relationship between preoperative hypoalbuminemia and postoperative pneumonia following geriatric hip fracture surgery: a propensity-score matched and conditional logistic regression analysis. Clin Interv Aging. 2022;13:17.
34. Shin KH, Kim JJ, Son SW, Hwang KS, Han SB. Early postoperative hypoalbuminaemia as a risk factor for postoperative pneumonia following hip fracture surgery. Clin Interv Aging. 2020;6:15.
35. Lv H, Yin P, Long A, Gao Y, Zhao Z, Li J, Zhang L, Zhang L, Tang P. Clinical characteristics and risk factors of postoperative pneumonia after hip fracture surgery: a prospective cohort study. Osteoporos Int. 2016;27(10):3001–9.
36. Aquilani R, Zuccarelli GC, Condino AM, et al. Despite inflammation, supplemented essential amino acids may improve circulating levels of Albumin and Haemoglobin in patients after hip fractures. Nutrients. 2017;9(6):637.
37. Modig K, Erdefelt A, Mellner C, Cederholm T, Talbäck M, Hedström MJJ. Obesity paradox holds true for patients with hip fracture: a registry-based cohort study. J Bone Joint Surg Am. 2019;101(10):888–95.
38. Prieto-Alhambra D, Premaor MO, Avilés FF, Castro AS, Javaid MK, Nogués X, Arden NK, Cooper C, Compston JE, Diez-Perez A. Relationship between mortality and BMI after fracture: a population-based study of men and women aged ≥ 40 years. J Bone Min Res. 2014;29(8):1737–44.
39. Li J, Li D, Wang X, Zhang L. The impact of body mass index on mortality rates of hip fracture patients: a systematic review and meta-analysis. Osteoporos Int. 2022;33(9):1859–69.
40. Hedström M, Ljungqvist O, Cederholm T. Metabolism and catabolism in hip fracture patients: nutritional and anabolic intervention–a review. Acta Orthop. 2006;77(5):741–7.
41. Hanna JS. Sarcopenia and critical illness: a deadly combination in the elderly. JPEN J Parenter Enter Nutr. 2015;39(3):273–81.
42. Deng CH, Chen XH, Yin ZH, Jiang Y, Tan XJ. Expert consensus on perioperative nursing management of nutrition for elderly patients with hip fractures (version 2023). Chin J Trauma. 2023;39(5):394–403.
43. Department of Medical Administration of National Health Commission of the People's Republic of China. Guidelines for the treatment and management of hip fracture in older people (2022 edition). J Clin Orthop Res. 2023;8(2):77–83.
44. Simunovic N, Devereaux PJ, Sprague S, Guyatt GH, Schemitsch E, DeBeer J, Bhandari M. Effect of early surgery after hip fracture on mortality and complications: systematic review and meta-analysis. Can Med Assoc J. 2010;182:1609–16.
45. Vidal E, Moreira-Filho D, Pinheiro R, Souza RC, Almeida L, Camargo K Jr., Boas P, Fukushima F, Coeli C. Delay from fracture to hospital admission: a new risk factor for hip fracture mortality? Osteoporos Int. 2012;23(12):2847–53.
46. Kim SD, Park SJ, Lee DH, Jee DL. Risk factors of morbidity and mortality following hip fracture surgery. Korean J Anesthesiol. 2013;64(6):505–10.
47. Bokshan SL, Marcaccio SE, Blood TD, Hayda RA. Factors influencing survival following hip fracture among octogenarians and nonagenarians in the United States. Injury. 2018;49(3):685–90.
48. Jang SY, Cha YH, Yoo JI, Oh T, Kim JT, Park CH, Choy WS, Ha YC, Koo KH. Blood transfusion for Elderly patients with hip fracture: a Nationwide Cohort Study. J Korean Med Sci. 2020;35(37):e313.
49. Smeets SJM, Verbruggen J, Poeze M. Effect of blood transfusion on survival after hip fracture surgery. Eur J Orthop Surg Traumatol. 2018;28(7):1297–303.

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