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Postoperative prognostic factors for inability to walk at 6 weeks after fragility hip fracture surgery: A retrospective cohort study

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Abstract. Fragility hip fractures are highly prevalent among the elderly and are associated with substantial morbidity, disability and increased mortality. The inability to regain ambulation after surgery substantially diminishes quality of life. The identification of factors influencing postoperative ambulatory recovery is essential for optimizing patient outcomes. The present study aimed to identify postoperative prognostic factors associated with the inability to walk at 6 weeks post-surgery in patients with fragility hip fractures. This retrospective cohort study reviewed electronic medical records of patients aged ≥50 years who sustained intertrochanteric, subtrochanteric or femoral neck fractures between October 1, 2018, and September 30, 2023. At 6 weeks postsurgery, patients were categorized as either ambulatory or non-ambulatory. Univariable and multivariable risk ratio (mRR) regression analyses were conducted to identify postoperative prognostic factors associated with ambulatory status. Among 432 patients (72.5% women; age 76.8±9.6 years), 325 (75.2%) regained ambulation at 6 weeks, while 107 (24.8%) remained non-ambulatory. The inability to walk at hospital discharge [mRR, 25.3; 95% confidence interval (CI), 10.02-63.75; P<0.001], postoperative need for oxygen support (mRR, 1.33; 95% CI, 1.01-1.75; P=0.038) and the presence of overall postoperative complications within 6 weeks after discharge (mRR, 1.23; 95% CI, 1.01-2.32; P=0.043) were significant prognostic factors for non-ambulation. In conclusion, the key prognostic factors identified were the inability to walk at hospital discharge, the postoperative need for oxygen support and subacute postoperative complications within 6 weeks after discharge. These findings underscore the importance of early complication detection and management in promoting recovery and improving functional outcomes.

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Abbreviations: ADL, activities of daily living; CCI, Charlson Comorbidity Index; CI, confidence interval; EMR, electronic medical records; Hct, hematocrit; ICU, Intensive Care Unit; LOS, length of stay; mRR, multivariable risk ratio; OR, odds ratio

Key words: prognostic factors, fragility hip fracture, inability to walk, retrospective cohort study

Introduction

The global geriatric population is expanding rapidly, with individuals aged ≥65 years projected to more than double in the coming decades, reaching ~2.2 billion by the late 2070s (1). Thailand transitioned to an aged society as the proportion of its population aged ≥60 years reached approximately 20%, reflecting significant demographic aging in recent years (2). Aging is associated with multisystem decline, particularly in the musculoskeletal system, which increases vulnerability to low-energy fragility injuries. Among these, hip fractures are common and represent a major public health concern due to their association with disability, reduced quality of life, elevated mortality and substantial healthcare costs (3,4). In the United States, hospitalization costs for hip fractures exceed $30 billion annually, while in Japan they reach ~$2.99 billion (5,6). Across Asia, fragility fractures are projected to nearly double by 2050, with direct costs increasing from $9.5 billion in 2018 to $15 billion (7). In Thailand, hip fractures with hospitalization costs increased 2.5-fold between 2013 and 2022 (8). Globally, hip fracture incidence is estimated at 182 cases per 100,000 individuals (95% uncertainty interval, 142-231) (9). In Thailand, the incidence of hip fractures increased annually from 2013 to 2019 before stabilizing between 2019 and 2022, with the age-standardized incidence rate rising from 116.3 cases per 100,000 individuals in 2013 to 145.1 cases in 2019, with a slight decline to 140.7 cases in 2022 (8).

Within the Thai context, fragility or osteoporotic fractures are defined as hip fractures resulting from low-energy traumatic mechanisms in individuals aged ≥50 years (10). Surgical intervention remains the standard treatment, aiming to reduce mortality and prevent long-term disability. However, postoperative functional and ambulatory recovery is often suboptimal and varies considerably across studies (11-13). Previous reports have indicated that 40-60% of patients regain pre-fracture mobility and instrumental activities of daily living (ADLs) within 3 to 6 months post-surgery (13,14), while more recent evidence has suggested that at 3 months, only 20%

achieve satisfactory ambulation and 21.5% regain pre-injury walking ability (15). Nearly 30% fail to recover ADLs within 1 year (16), and registry data from Japan show that ~10% of previously ambulatory patients remain unable to walk at 4 months (17). Furthermore, a systematic review concluded that despite advances in anesthesia, perioperative care and rehabilitation, the 1-year mortality rate remains substantial, with a mean of 22% (range, 2.4-34.8%) and marked variation across populations (18). Ambulatory ability is an essential functional capacity in older adults, enabling them to carry out basic ADLs and maintain social participation through community ambulation (19). Therefore, early rehabilitation training after hip fracture surgery, encompassing mobility, transfer and ambulation training, is crucial for preventing complications from prolonged bed rest and enabling patients to regain mobility and independent ambulation (20-22).

Recovery of ambulatory capacity after hip fracture surgery depends on multiple factors, including preoperative, intraoperative and postoperative conditions (23). While several studies have examined preoperative and perioperative predictors (24-26), relatively few have focused on postoperative prognostic factors (27,28). Postoperative complications play a crucial role in determining functional outcomes after hip fracture surgery. Prolonged Intensive Care Unit (ICU) stays, and the need for ventilator support have been associated with increased long-term morbidity and increased mortality rates (23,29). Tangchitphisut *et al* (23) reported that postoperative ICU admission or ventilator use was significantly more common among patients who were unable to bear self-weight at discharge (10/55 patients, 18.2%; P<0.001). Similarly, Eschbach *et al* (29) found that geriatric hip-fracture patients requiring prolonged ICU care (>3 days) had markedly higher in-hospital, 6-month and 12-month mortality rates compared with those with shorter ICU stays (P=0.001). Furthermore, postoperative complications such as infections (particularly pressure ulcers), delirium, arrhythmias and respiratory issues have been linked to poorer functional and mobility outcomes (13,23,30). Recent evidence has also identified postoperative medical complications as the most significant risk factor for persistent walking disability (23,24,27). Although hip fractures profoundly affect both short and long-term outcomes, evidence regarding prognostic factors for ambulation during the early subacute period remains limited. Early identification of patients at high risk for impaired ambulation is essential to guide postoperative management, optimize rehabilitation and support caregiver planning. The 6-week timeframe represents a clinically relevant milestone, coinciding with routine follow-up, facilitating timely rehabilitation and enabling recognition of patients at risk of delayed recovery before longer-term outcomes are established. To address this gap, the present study aimed to identify postoperative prognostic factors associated with the inability to ambulate 6 weeks after fragility hip fracture surgery.

Materials and methods

Study design and setting. This retrospective cohort study was conducted at a tertiary care referral center, Hatyai Hospital (Songkhla, Thailand). Data were obtained from electronic medical records (EMRs) of patients treated between October 1, 2018, and September 30, 2023. The inclusion criteria were as follows: i) Age ≥50 years; ii) diagnosis of a single, closed hip fracture resulting from low-energy trauma; iii) a fracture classified as a femoral neck, intertrochanteric or subtrochanteric fracture, identified by specific International Classification of Diseases (ICD)-10 codes (31) (S72.000-S72.019, S72.100-S72.101, S72.110-S72.111 and S72.200-S72.210); and iv) surgical treatment for a hip fracture, identified using ICD-9 (32) procedure codes (79.15, 79.25, 79.35, 81.51, and 81.52). The exclusion criteria were as follows: i) Hip fractures secondary to pathological conditions (for example. malignancy); ii) multiple traumatic injuries sustained during the same admission; iii) fractures caused by high-energy trauma; iv) periprosthetic fractures or fractures involving previous nail fixation; v) conservative (non-surgical) management; vi) pre-fracture bedridden status or wheelchair dependence; vii) in-hospital mortality before discharge; and viii) incomplete or missing EMR data during the study period. The study was approved by the Human Research Ethics Committee of Hatyai Hospital (approval no. HYH EC 007-67-01).

Surgical intervention was performed using procedures appropriate for the specific type of hip fracture. Following surgery, all patients underwent a standardized postoperative rehabilitation program based on the recommendations of the American Academy of Orthopedic Surgeons (21) and the National Institute for Health and Care Excellence (22). The program was designed to promote functional recovery and ambulation, with individual modifications made according to patient centered care principles that considered physical status, comorbidities, surgical procedure and overall tolerance. The rehabilitation protocol for ambulatory training emphasized early mobilization and included bed mobility exercises, transitions from supine to sitting, sitting balance activities, sit to stand transfers, safe pivot transfers from bed to chair or wheelchair and standing balance training. Once the patient demonstrated adequate stability, ambulation training with walking practice was introduced. Patients were encouraged to ambulate with a walker and to practice partial weight bearing on the surgical limb as tolerated. Each training session was conducted once daily for ~20 to 30 min. Routine follow-up evaluations were performed at 6 weeks postsurgery to monitor recovery, assess ambulatory status, and address ongoing complications and care needs.

Data collection. A retrospective review was conducted using the EMRs of 432 patients who underwent hip fracture surgery. Data collected included admission dates, clinical characteristics and postoperative variables considered potential prognostic factors for the inability to walk 6 weeks after surgery. Candidate postoperative predictors included: i) Postoperative ICU admission or ventilator use (23,29), which was defined to include either ICU admission regardless of ventilator support or endotracheal intubation with mechanical ventilation, in the ICU or elsewhere; ii) need for postoperative oxygen support (33,34), referred to any supplemental oxygen via nasal cannula, face mask or high-flow oxygen, administered to prevent hypoxemia and maintain a peripheral oxygen saturation level generally ≥95% (unless contraindicated); iii) urinary catheter use on the second postoperative day (23,35); iv) the presence of postoperative surgical complications (33,36), such as postoperative weight-bearing restrictions due to poor bone quality or revision surgery following fixation failure; v) anemia from postoperative blood loss (37); vi) the presence of postoperative medical complications (33,38) (such as pressure ulcers, urinary tract infection and pneumonia); vii) time to initiation of functional training (39-41) (<48, 48-72 and >72 h post-operation); viii) the ability to walk at hospital discharge; ix) the length of stay (LOS) (42); and x) the presence of overall complications within 6 weeks after discharge (23,27,33), classified as surgical, medical or mental-health related. The primary endpoint was ambulatory status 6 weeks after surgery. Patients were classified into two groups based on discharge ambulation: i) a non-ambulatory group, consisting of patients who were bedridden or wheelchair-dependent; and ii) an ambulatory group, consisting of patients who could walk independently or with the aid of a walking device.

Sample size calculation. The determination of an appropriate sample size for logistic regression typically necessitates a minimum of 5 to 10 events per candidate predictor parameter to ensure model reliability. Given that the present study included 14 exploratory variables (10 postoperative factors and 4 demographic factors to adjust the model), the corresponding requirement ranged from 90 to 140 events (43,44). Considering that the prevalence of inability to walk in this study was 24.8%, a total sample size between 364 and 565 participants was deemed optimal.

Statistical analysis. Statistical analysis was conducted using the Stata Statistical Package (version 18.0; Stata Corp LLC). Categorical variables are presented as frequencies and percentages, while continuous variables are reported as means and standard deviations for normally distributed data or medians and interquartile ranges for skewed data. To compare proportions between the two groups (i.e., inability or ability to walk 6 weeks after fragility hip fracture surgery), the χ^2 test was used. When the expected cell count was less than five, Fisher's exact test was applied. Continuous variables were compared using Student's t-test for parametric data or a Mann-Whitney U test for non-parametric data, depending on the distribution. Variables with clinical relevance and those with P<0.25 (45-47) in an initial screening were included in the univariable analysis, with results presented as univariable risk ratios. To identify factors associated with the inability to walk 6 weeks after fragility hip fracture surgery, a multivariable Poisson regression model was fitted with a log link and robust standard errors (48). The model was adjusted for age, sex, Charlson Comorbidity Index (CCI) (49) and fracture type. The binary outcome was the ability/inability to walk at 6 weeks, and multivariable risk ratios (mRRs) with 95% confidence intervals (CIs) were estimated. Two-sided P<0.05 was considered statistically significant. Multicollinearity among covariates was assessed using variance inflation factors (VIF), with a VIF value of <5 considered acceptable (50). During variable selection, it was found that ambulatory training and the inability to walk at discharge were collinear, and a significant association was observed between the two variables. As they are also theoretically expected to be correlated, a pragmatic approach was used to determine which variable contributed more effectively to the multivariable model (51). Inability to walk at discharge yielded a higher adjusted R-squared value and was therefore retained in the final model. All other postoperative predictors included in the analysis had VIF values <5.

Results

Study population and exclusions. A total of 629 patients with fragility hip fractures underwent surgery. Of these, 97 patients were excluded for the following reasons: 23 experienced high-energy trauma, 13 sustained multiple injuries, 10 had pathological fractures, 1 had a periprosthetic fracture, 4 died during admission, 1 required prolonged hospitalization due to the absence of a caregiver, 5 were unable to walk prior to the fracture and 40 had incomplete data collection. Consequently, 532 patients were left for the present analysis. However, 100 patients were lost to follow-up at 6 weeks postoperatively, resulting in a final study population of 432 patients. There were no statistically significant differences in baseline characteristics [age, sex, CCI, preoperative hematocrit (Hct) and fracture type] between patients who completed follow-up and those who were lost to follow-up (Table SI). The majority of included participants were female (313 patients, 72.5%) and overall age was 76.8±9.6 years (range, 52-100 years).

Comparative analysis of ambulatory and non-ambulatory patient groups at 6 weeks postoperatively. At 6 weeks post-surgery, 325 patients (75.2%) regained the ability to walk, while 107 patients (24.8%) remained non-ambulatory (Fig. 1). No statistically significant differences were observed between groups regarding BMI, smoking status, and glomerular filtration rate. However, Hct levels were significantly lower in the non-ambulatory group (31.3 vs. 33.4%; P<0.001). When comparing the two groups, the inability-to-walk group showed a significantly higher proportion of female patients (81.3 vs. 69.5%; P=0.018), higher mean age (79.3±9.6 vs. 76.0±9.4 years; P=0.001) and a lower proportion of pre-fracture independent community ambulation (35.5 vs. 71.7%; P<0.001). Additionally, this group exhibited a significantly higher prevalence of underlying diseases (92.5 vs. 82.8%; P=0.014), including diabetes mellitus, cerebrovascular disease, Parkinson's disease, Alzheimer's disease or dementia, heart disease and musculoskeletal disorders. Furthermore, significant differences were found between the non-ambulatory and ambulatory group in the proportion of patients who sustained indoor falls (88.8 vs. 79.4%; P=0.049) and the distribution of fracture types (P=0.002) (Table I).

Postoperative factors associated with ambulatory status. Regarding postoperative factors, patients in the non-ambulatory group at 6 weeks after fragility hip fracture surgery exhibited a significantly higher need for postoperative oxygen support (59.8 vs. 40.6%; P=0.001), urinary catheter use on the second postoperative day (62.6 vs. 50.5%; P=0.029), presence of postoperative surgical complications (11.2 vs. 1.8%; P<0.001) and presence of postoperative medical complications (39.2 vs. 22.5%; P=0.001). Additionally, LOS (≥14 days) was more prevalent among patients who remained unable to walk (35.5 vs. 15.4%; P<0.001), as was the occurrence of postoperative complications within 6 weeks after discharge (16.8 vs. 3.1%; P<0.001). Conversely, the attainment of ambulation training was significantly higher in the group that regained

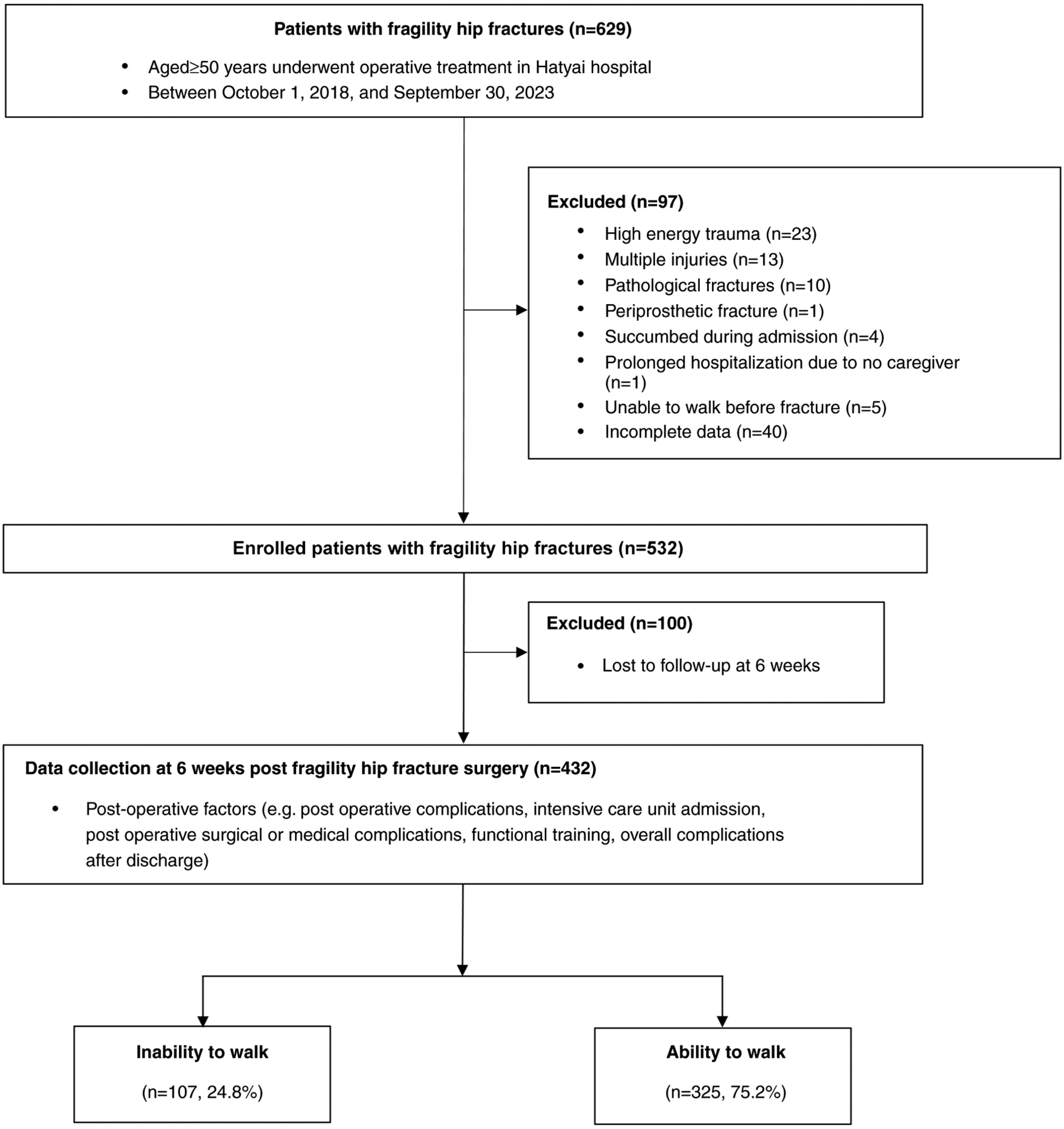

Figure 1. Flow diagram of patient inclusion in the present study.

walking ability compared with that in the non-ambulatory group (86.1 vs. 28.4%; P<0.001) (Table II).

Regression analysis results. The results of univariable and multivariable regression analyses are presented in Table III. In the univariate analysis, several factors emerged as significant predictors, including postoperative ICU admission or ventilator use, the need for postoperative oxygen support, urinary catheter use on the second postoperative day, the presence of postoperative surgical complications, the presence of postoperative medical complications, time to start functional training (>72 h post-operation), inability to walk at hospital discharge, LOS (≥14 days), and the occurrence of overall complications within 6 weeks post-discharge. However, the multivariable regression analysis identified only the following key prognostic factors: Inability to walk at discharge (mRR, 25.3; 95% CI, 10.0-63.8; P<0.001), postsurgery need for oxygen support (mRR, 1.33; 95% CI, 1.01-1.75; P=0.038) and the presence of overall postsurgery complications within 6 weeks after discharge (mRR, 1.23; 95% CI, 1.01-2.32; P=0.043) (Fig. 2).

Discussion

Hip fractures rank among the most serious fractures in elderly individuals, often leading to impaired function, and increased morbidity and mortality rates (13,52). Elderly patients

Table I. Comparison of patients' demographic and clinical characteristics between groups with the inability and ability to walk at 6 weeks after fragility hip fracture surgery (n=432).

Variables	Inability to walk (n=107)	Ability to walk (n=325)	P-value
Female, n (%)	87 (81.3)	226 (69.5)	0.018
Age, years[a]	79.3±9.6	76.0±9.4	0.002
Body mass index, kg/m^2[a]	22.3±4.5	22.5±4.1	0.577
Smoking, n (%)	7 (6.5)	37 (11.4)	0.711
Pre fracture community walking independent, n (%)	38 (35.5)	233 (71.7)	<0.001
Underlying diseases, n (%)	99 (92.5)	269 (82.8)	0.014
Hypertension	82 (76.6)	217 (66.8)	0.055
Diabetes mellitus	40 (37.4)	88 (27.1)	0.043
Dyslipidemia	51 (47.7)	125 (38.5)	0.093
Cerebrovascular disease	33 (30.8)	43 (13.2)	<0.001
Parkinson's disease	6 (5.6)	5 (1.5)	0.020
Alzheimer's/dementia	12 (11.2)	15 (4.6)	0.014
Heart disease (AF/VHD/IHD)	16 (15.0)	23 (7.1)	0.014
Pulmonary disease	6 (5.6)	40 (12.3)	0.051
Anemia	15 (14.0)	36 (11.1)	0.413
Musculoskeletal problems	19 (17.8)	34 (10.5)	0.046
Charlson Comorbidity Index[a]	5.0±1.7	4.1±1.5	<0.001
Falling indoors, n (%)	95 (88.8)	258 (79.4)	0.049
Fracture types, n (%)			0.002
Subtrochanteric fracture of the femur	3 (2.8)	5 (1.5)	
Intertrochanteric fracture of the femur	69 (64.5)	152 (46.8)	
Femoral neck fracture	35 (32.7)	168 (51.7)	
Preoperative hematocrit, %[a]	31.3±5.0	33.4±5.2	<0.001
Glomerular filtration rate, ml/min[a]	74.0±26.5	81.0±48.8	0.166

[a]Data are presented as the mean ± SD. AF, atrial fibrillation; VHD, valvular heart disease; IHD, ischemic heart disease.

undergoing hip fracture surgery frequently exhibit physical instability in the acute postoperative phase, which may delay the initiation of rehabilitation (53,54). Previous research has demonstrated that by 6 weeks postsurgery, patients typically exhibit improved physical stability, enabling participation in rehabilitation programs; however, vigilant monitoring for potential complications remains imperative (27,55). The present study aimed to identify prognostic factors associated with the inability to walk at 6 weeks following fragility hip fracture surgery. The findings emphasize the inability to walk at discharge, the postoperative need for oxygen support and the presence of postoperative complications within 6 weeks as significant predictors of ambulatory outcomes.

The presence of overall complications after discharge within 6 weeks increased the risk of the inability to walk at 6 weeks post-fragility hip fracture surgery by 1.23 times (95% CI, 1.01-2.32; P=0.043). Similarly, Chanthanapodi *et al* (27) reported that postoperative medical complications within the first 6 weeks were the strongest prognostic factor for the inability to walk 6 weeks after surgery, with a risk ratio (RR) of 2.04 (95% CI, 1.37-3.02; P<0.001). However, the findings of the present study contrast with those in the study by Monkuntod *et al* (56), which was a prospective observational cohort study on older adults diagnosed with hip fractures, scheduled for surgery and followed up for 2 weeks postoperatively at three tertiary care hospitals. The study found that adverse health outcomes during and after hospitalization did not predict poor functional ability at discharge. This discrepancy may be attributed to the shorter duration of complication recording (2 weeks) compared with both the present study and the research conducted by Chanthanapodi *et al* (27). Empirical evidence suggests that early identification of postoperative complications during the acute to subacute rehabilitation phase is crucial in facilitating functional recovery (33,55,57).

Ambulatory ability is a key concern for both patients and caregivers (58). Since walking ability is a crucial indicator of functional recovery, it remains a primary focus for patients undergoing surgery for fragility hip fractures during the postoperative period (59). Previous research has demonstrated that patients with hip fractures who regain early walking ability have significantly higher survival rates at both 1- and 10-years post-surgery (60). Adulkasem *et al* (61) reported that both pre-injury ambulatory status [odds ratio (OR), 52.72; 95% CI, 5.19-535.77] and ambulatory status at discharge (OR, 8.5; 95% CI, 3.33-21.70) were strong prognostic factors for postoperative functional recovery, underscoring the importance of baseline mobility. Similarly, the present study demonstrated

Table II. Comparison of patients' post-operative factors between groups with the inability and ability to walk at 6 weeks after fragility hip fracture surgery.

Variables	Inability to walk (n=107)	Ability to walk (n=325)	P-value
Postoperative ICU admission or ventilator use, n (%)	7 (6.5)	9 (2.8)	0.082
Postoperative need for oxygen support, n (%)	64 (59.8)	132 (40.6)	0.001
Urinary catheter used in the second day post operative, n (%)	67 (62.6)	164 (50.5)	0.029
Presence of post operative surgical complications, n (%)	12 (11.2)	6 (1.8)	<0.001
Anemia due to post operative blood loss, n (%)	45 (42.1)	107 (32.9)	0.086
Presence of the post operative medical complications, n (%)	42 (39.3)	73 (22.5)	0.001
Time to start functional training, n (%)			0.056
<24 h post-operation	43 (40.2)	168 (51.7)	
24-48 h post-operation	32 (29.9)	92 (28.3)	
>72 h post-operation	30 (29.9)	65 (20.0)	
Type of functional training, n (%)			
Mobility training	106 (99.1)	327 (100.0)	0.081
Transfer training	107 (100.0)	323 (99.4)	0.416
Ambulation training	30 (28.0)	280 (86.2)	<0.001
Inability to walk at discharge, n (%)	102 (95.3)	72 (22.2)	<0.001
Length of stay ≥14 days, n (%)	38 (35.5)	50 (15.4)	<0.001
Presence of the overall complications within 6 weeks after discharge, n (%)	18 (16.8)	10 (3.1)	<0.001

ICU, Intensive Care Unit.

Table III. uRR and mRR of post-operative prognostic factors of patients with the inability to walk at 6 weeks after fragility hip fracture surgery.

	Univariable analysis			Multivariable analysis		
Variables	uRR	95% CI	P-value	mRR	95% CI	P-value
Postoperative ICU admission or ventilator use	1.82	1.02-3.25	0.043	0.89	0.49-1.63	0.717
Postoperative need for oxygen support	1.79	1.28-2.51	0.001	1.33	1.01-1.75	0.038
Urinary catheter used in the second day post operative	1.46	1.03-2.05	0.031	1.06	0.81-1.39	0.681
Presence of post operative surgical complications	2.9	2.00-4.21	<0.001	1.29	0.92-1.81	0.135
Anemia due to post operative blood loss	1.34	0.96-1.85	0.084	0.90	0.68-1.17	0.431
Presence of the post operative medical complications	1.78	1.29-2.46	<0.001	0.92	0.71-1.21	0.572
Time to start functional training						
<48 h post-operation		Reference			Reference	
48-72 h post-operation	1.27	0.84-1.89	0.248	1.05	0.77-1.43	0.746
>72 h post-operation	1.62	1.10-2.39	0.015	0.92	0.67-1.27	0.620
Inability to walk at discharge	30.2	12.58-72.7	<0.001	25.3	10.02-63.75	<0.001
Length of stay ≥14 days	2.15	1.56-2.96	<0.001	1.25	0.94-1.65	0.119
Presence of the overall complications within 6 weeks after discharge	2.82	2.02-3.92	<0.001	1.23	1.01-2.32	0.043

The multivariable risk ratio model was adjusted for age, sex, Charlson Comorbidity Index and fracture type (subtrochanteric, intertrochanteric or femoral neck). mRR, multivariable risk ratio; uRR, univariable risk ratio; ICU, Intensive Care Unit.

a high effect estimate for the inability to walk at discharge (mRR, 25.3; 95% CI, 10.02-63.75), although the wide confidence interval observed may reflect the modest sample size and a potential risk of model overfitting. The higher effect estimates in the present study compared with those reported by Adulkasem *et al* (15,61) are likely attributable

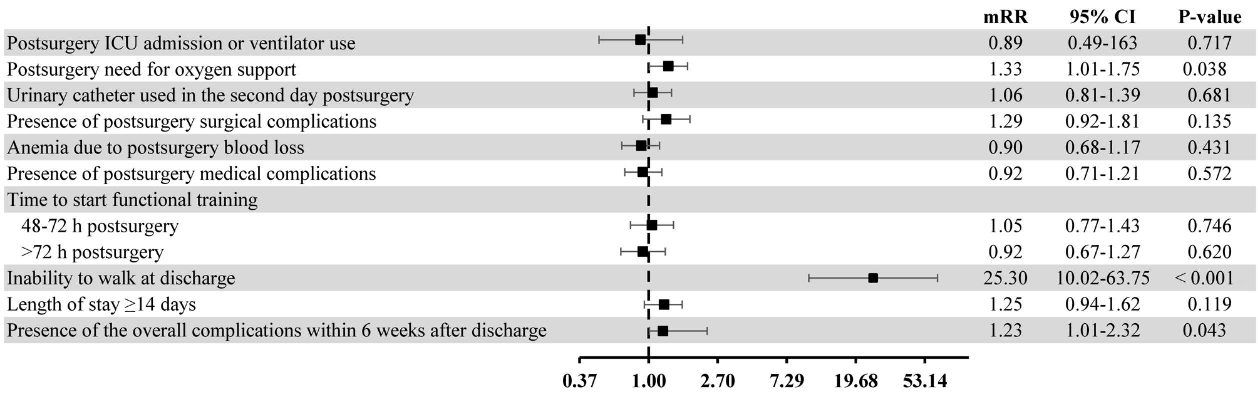

Figure 2. Forest plot showing mRR of post-operative prognostic factors of the inability to walk at 6 weeks after fragility hip fracture surgery. mRR, multivariable risk ratio; CI, confidence interval; ICU, Intensive Care Unit.

to differences in study populations and model specifications. While Adulkasem *et al* (15,61) included patients across all baseline walking abilities, including those who were non-ambulatory prior to hip fracture, the present cohort was restricted to individuals who were ambulatory before the fracture. Furthermore, the previous study analyses incorporated both pre-fracture and discharge ambulatory status as predictors, whereas the present model included only ambulatory ability at discharge. Limiting the sample to pre-fracture ambulatory patients and including a single post-fracture mobility variable may have contributed to the more pronounced effect size observed.

The postoperative need for oxygen therapy was a significant predictor of inability to walk at 6 weeks in the present study. While chest physiotherapy and bed-mobility exercises can be initiated with supplemental oxygen, achieving adequate oxygenation on room air is an essential milestone before commencing ambulation training in Hatyai Hospital. Dependence on oxygen supplementation may therefore be associated with delayed ambulation, a condition linked to an increased risk of medical complications, higher mortality rate and prolonged hospital stay (62,63). In line with this, the Clinical Insights on Thailand Postoperative Hip Fracture Care (20) recommend early mobilization programs for patients undergoing surgery for fragility hip fractures.

Although postoperative ICU admission or ventilatory support were significant in the univariate analysis, they were not significant in the multivariate model. This finding aligns with a previous study that reported no significant increase in the risk of an inability to self-bear weight at discharge among patients admitted to the ICU postoperatively or requiring ventilatory support. ICU admission and ventilatory support primarily address acute postoperative complications that are often transient and treatable with current medical interventions; therefore, they may not serve as indicators of long-term functional recovery. Additionally, these factors were associated with other stronger predictors included in the model, such as overall postoperative complications and ability to ambulate at discharge. After adjustment for these variables, ICU/ventilator use and early complications were no longer significant, suggesting that their effects were largely accounted for by these stronger predictors.

The presence of postoperative surgical complications, the presence of postoperative medical complications, urinary catheter usage on the second postoperative day and a LOS of ≥14 days were significant predictors in the univariate analysis but not in the multivariate model in the present study. Previous studies have reported conflicting findings regarding postoperative complications. While several studies have reported an association between postoperative surgical and medical complications and poorer mobility outcomes (27,64,65), the study by Tangchitphisut *et al* (23) found no such association. One study identified urinary catheter use as a significant predictor (35), whereas another reported no association (23). Similarly, although earlier studies reported LOS as a significant predictor (25,66), subsequent research did not confirm this association (67). Importantly, while acute postoperative complications were not independent predictors in the present multivariate analysis, late complications occurring after discharge were significantly associated with poorer walking ability. This observation supports the hypothesis that early postoperative complications may reflect transient conditions amenable to contemporary medical management, whereas late complications may exert a more profound and lasting impact on functional recovery.

Despite providing valuable insights, the present study has several limitations that warrant consideration. The single-center design may limit generalizability. Also, the final analysis included 432 patients, of whom 107 were unable to walk. With 14 variables, the events-per-variable (EPV) ratio was 7.6 (107/14), falling within the commonly accepted 5-10 range for exploratory analyses (43,44). Nevertheless, a modestly low EPV may increase the risk of model overfitting, potentially leading to wider confidence intervals and inflated effect estimates for some variables. Resource constraints such as bed shortages also necessitated early discharges and patient transfers based on healthcare coverage policies, potentially introducing referral bias that influenced outcomes. In addition, the retrospective design required excluding patients with incomplete data, which may have reduced statistical power and could potentially lead to under- or overestimation of prognostic factors. The outcome 'inability to walk' provides a simple measure of functional recovery but may not fully capture other aspects of postoperative function, such as independence in ADLs or mobility scores. The present study was designed to explore postoperative predictive factors rather than to develop or validate a formal predictive model. Development of a robust, clinically applicable model would require a larger sample and further research. The factors identified here should therefore be interpreted as potential predictors that may help clinicians remain vigilant when caring for patients who present with these characteristics. Finally, although multidisciplinary rehabilitation teams play a critical role in postoperative care, early identification of prognostic indicators for functional recovery remains insufficiently understood. This highlights the need for prospective, multicenter studies incorporating comprehensive geriatric assessments and rehabilitation-specific variables and outcomes to better identify patients who may benefit from additional rehabilitation support.

In conclusion, the present study identified three key prognostic factors for early functional recovery at 6 weeks after fragility hip fracture surgery: The ability to ambulate at hospital discharge, the postoperative need for oxygen support and the presence of overall postoperative complications within 6 weeks. Early rehabilitation and proactive management of medical complications are critical strategies to enhance post-operative mobility and improve long-term outcomes in this vulnerable patient population.

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Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

TJ performed data collection and analysis, wrote the original draft of the manuscript, and prepared all materials. PL contributed to the data collection. JS performed data analysis and coordination, as well as supervised and revised the manuscript. TJ, PL and JS contributed to the conceptual and methodological design of the study. All authors have read and approved the final version of the manuscript. TJ and JS confirm the authenticity of all the raw data.

Ethics approval and consent to participate

The protocol of this study was approved by the Human Research Ethics Committee of Hatyai Hospital (Songkhla, Thailand; approval no. HYH EC 007-67-01). All procedures involved in this study followed the ethical standards of and complied with the Declaration of Helsinki.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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