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Original Article

Effect of unaccompanied care model in postoperative care for elderly patients with lower limb fractures: factors influencing postoperative heart failure

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Abstract: Objective: To evaluate the effect of the unaccompanied care model on postoperative nursing for elderly patients with lower limb fractures (LLFs) and identify factors influencing postoperative heart failure (HF). Methods: A total of 215 elderly patients diagnosed with LLFs who received conventional treatment between January and December 2023 were enrolled as the control group. Another 215 elderly patients with LLFs treated from January to December 2024 were included as the observation group, who received unaccompanied care in addition to conventional treatment. Results: At postoperative day 7 and month 6, the observation group obtained significantly higher Fugl-Meyer Assessment for lower limb motor function and Barthel Index for activities of daily living than the control group (both $P < 0.001$). On postoperative day 7, the observation group had a higher left ventricular ejection fraction (LVEF), lower left ventricular end-diastolic diameter (LVEDD) and lower B-type natriuretic peptide (BNP) levels relative to the control group (all $P < 0.01$). At postoperative month 6, the observation group showed superior left ventricular end-systolic diameter (LVESD), LVEDD, LVEF, and BNP profiles compared to the control group (all $P < 0.01$). In addition, the observation group had higher serum Klotho and decoy receptor 3 levels and lower salusin-β levels at postoperative month 6 (all $P < 0.05$). The observation group also had significantly shorter affected limb swelling regression time, earlier off-bed ambulation time, and shorter hospital stay (all $P < 0.05$). The overall complication rate was 21.4% in the observation group versus 33.5% in the control group ($P < 0.05$). Multivariate analysis demonstrated that advanced age, American Society of Anesthesiologists (ASA) physical status classification, preoperative BNP level and Klotho level were independent risk predictors of postoperative HF in elderly patients undergoing lower limb fracture surgery (all $P < 0.05$). The established nomogram presented good discriminatory power [area under the curve (AUC) = 0.879] and calibration performance, and SHAP analysis further verified the predictive validity of the model. Conclusion: The unaccompanied care model can improve lower limb motor function, activities of daily living and cardiac function, ameliorate abnormal serum inflammatory biomarker levels, and reduce postoperative complication risks for elderly patients with LLFs. Age, ASA classification, BNP and Klotho were independent predictors of postoperative HF. The nomogram model has robust predictive performance and promising clinical application value.

Keywords: Unaccompanied care model, elderly lower limb fractures, heart failure, prediction model

Introduction

Clinically, femoral neck fractures, intertrochanteric fractures and tibiofibular fractures are the most prevalent types of lower limb fracture. Surgical intervention is currently the primary treatment for elderly patients with such fractures [1]. However, surgical trauma can induce intense physiological stress in elderly individuals, which not only hinders postoperative limb functional recovery but also increases the risk of secondary complications including deep venous thrombosis, pulmonary infection, and pressure injuries. Notably, postoperative heart failure (HF) is a life-threatening cardiovascular complication with high morbidity and poor long-term prognosis, requiring rigorous clinical monitoring [2-4]. Epidemiologic data show that the incidence of postoperative HF among elderly lower limb fracture patients ranges from 6% to

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20%, and this complication significantly elevates patient mortality [5]. Previous studies reported that the 30-day mortality of fracture patients complicated to HF reaches 5.7%, and the 1-year mortality climbs to 25.2% [6]. Therefore, optimizing postoperative nursing protocols and clarifying postoperative HF risk factors are critical to accelerating patient recovery and preventing fatal cardiovascular adverse events.

Conventional orthopedic nursing mainly focuses on routine vital sign monitoring, incision dressing care, and basic rehabilitation guidance, which relies heavily on informal care from family caregivers. Most family members lack standardized nursing training, leading to substandard daily care and irregular rehabilitation guidance. Such informal care cannot meet the demands of refined, individualized nursing for elderly fracture patients [7, 8]. The unaccompanied care model is an emerging standardized nursing method adapted to population aging. Under this model, a dedicated nursing team composed of registered nurses and nursing assistants, undertakes full-round inpatient nursing services throughout admission to discharge, eliminating dependence on family companions. Individualized nursing plans, standardized operational workflows, and staged rehabilitation management ensure continuous, high-quality nursing services [9]. Existing clinical studies have validated its partial efficacy: Chen et al. [9] confirmed that unaccompanied care reduced perioperative delirium incidence in elderly hip fracture patients, while Netzer et al. [7] found structured geriatric orthopedic nursing outperformed conventional nursing in discharge arrangement and functional recovery. Nevertheless, evidence regarding its effects on cardiac function protection and long-term functional recovery in lower limb fracture patients remains insufficient, requiring further clinical validation.

Given the above research gaps, our hospital fully implemented the unaccompanied care model for postoperative orthopedic rehabilitation starting in January 2024. This retrospective study analyzed clinical data from 430 elderly lower limb fracture patients to compare clinical outcomes between conventional accompanied nursing and standardized unaccompanied nursing, screen independent influencing factors of postoperative HF, and construct and interpret a HF prediction nomogram via SHapley Additive Explanations (SHAP) analysis.

Materials and methods

Study design

Clinical data of 430 elderly patients who underwent lower limb fracture surgery at North China Medical and Health Group Xingtai General Hospital from January 2023 to December 2024 were retrospectively reviewed. Patients admitted between January and December 2023 receiving routine orthopedic nursing were assigned to the control group (n=215), and those admitted between January and December 2024 receiving routine nursing plus unaccompanied care were assigned to the observation group (n=215). To explore postoperative HF predictors, all enrolled patients were further divided into HF and non-HF subgroups based on whether HF occurred during the 6-month follow-up. This study was approved by the Ethics Committee of North China Medical and Health Group Xingtai General Hospital and conducted in strict accordance with the Declaration of Helsinki.

Inclusion criteria: (1) Aged 65 years or older; (2) Lower limb fracture confirmed via X-ray, CT or MRI, including femoral neck, intertrochanteric, tibial plateau, tibiofibular, or patellar fractures; (3) Received surgical treatment (internal fixation, arthroplasty or external fixation) within 7 days after traumatic injury; (4) Complete perioperative clinical data and follow-up records stored in the hospital information system; (5) Inpatient admission within the two predefined study periods.

Exclusion criteria: (1) Pathologic fractures secondary to malignant tumor or severe osteoporosis; (2) Polytrauma or concurrent fractures at non-lower limb sites; (3) Preoperative severe HF (New York Heart Association class III-IV) or cardiogenic shock; (4) End-stage hepatic dysfunction (Child-Pugh class C) or severe renal insufficiency (estimated glomerular filtration rate < 30 mL/min/1.73 m^2); (5) Pre-existing cognitive dysfunction or psychiatric disorders interfering with rehabilitation compliance; (6) Inter-hospital transfer within 72 hours after surgery; (7) Incomplete medical records or loss to follow-up within 6 months postoperatively.

Diagnostic and evaluation criteria

Lower limb fracture diagnostic criteria: Diagnosis was confirmed when all three items were met: (1) definite traumatic injury history; (2) local clinical manifestations including pain, swelling, deformity and limited mobility, accompanied by tenderness, percussion pain or abnormal limb movement on physical examination; (3) continuous bone cortex interruption or fracture lines detected on imaging examination [10].

Postoperative HF diagnostic criteria: The study-defined HF outcomes included new-onset acute HF or acute exacerbation of chronic HF during inpatient stay, diagnosed based on three concurrent indicators: (1) typical HF clinical manifestations (dyspnea, peripheral edema, jugular venous distension, pulmonary rales, or third heart sound); (2) auxiliary examination abnormalities (elevated N-terminal pro-BNP or pulmonary congestion confirmed by chest radiography); (3) targeted anti-failure intervention including diuretic or vasodilator administration [11].

Body mass index (BMI) classification: BMI was calculated as weight (kg) divided by square of the height (m^2). Classification standards: normal (18.5-23.9), overweight (24.0-27.9), obese (≥ 28.0) [12].

Smoking history definition: Consistent with World Health Organization (WHO) standards, smoking history referred to cumulative or continuous smoking for no less than 6 months throughout the lifespan. Patients who quit smoking for less than 12 months were still categorized as having a smoking history [13].

Alcohol consumption definition: (1) Long-term drinking: continuous drinking for over 5 years with daily ethanol intake ≥ 40 g for males and ≥ 20 g for females; (2) Recent heavy drinking: excessive ethanol intake within two weeks before admission [14].

Hypertension diagnostic criteria: Hypertension was diagnosed in two scenarios: first, untreated patients with systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg on three separate outpatient measurements; second, patients with documented hypertension receiving regular antihypertensive medication regardless of current blood pressure levels [15].

Hyperlipidemia diagnostic criteria: Hyperlipidemia was diagnosed if any of the following abnormalities were detected: low-density lipoprotein (LDL) ≥ 3.4 mmol/L, triglycerides (TG) ≥ 1.70 mmol/L, high-density lipoprotein (HDL) < 1.04 mmol/L, or total cholesterol (TC) ≥ 5.2 mmol/L [16].

Type 2 diabetes diagnostic criteria: Diabetes was diagnosed in patients with classic polyuria, polydipsia, polyphagia and unexplained weight loss plus any one of the following indicators: fasting blood glucose (FPG) ≥ 7 mmol/L, 2-hour postprandial blood glucose ≥ 11.1 mmol/L, or glycated hemoglobin (HbA1c) ≥ 6.5% [17].

Lower extremity soft tissue infection diagnostic criteria [18] required these 3 items: (1) local inflammatory signs (erythema, increased skin temperature, purulent discharge) or systemic fever and chills; (2) elevated inflammatory biomarkers (white blood cell count, C-reactive protein, erythrocyte sedimentation rate) or soft tissue inflammatory signals on MRI; (3) positive microbial culture of wound exudate or local tissue specimens.

Deep vein thrombosis (DVT) diagnostic criteria [19]: (1) Unilateral lower limb swelling, pain, superficial venous dilation or positive Homans sign; (2) Wells score ≥ 2 points indicating moderate to high DVT risk; (3) intraluminal filling defects or non-compressible venous lumen confirmed by venous ultrasound, CT venography or MR venography; (4) elevated plasma D-dimer. Isolated D-dimer elevation was not sufficient for definitive diagnosis and required imaging verification.

Pressure injury [20] was diagnosed based on the National Pressure Ulcer Advisory Panel unified standards: (1) localized non-blanchable erythema, blisters or full-thickness skin defects distributed over bony prominences or medical device compression sites; (2) lesions classified as stage 1-4 or unstageable deep tissue pressure injuries; (3) confirmed risk factors including prolonged bed rest, immobilization, sensory disturbance, malnutrition or persistent skin moisture.

Sample size estimation: Sample size was calculated based on published similar clinical studies [21]. With statistical power set at 0.8, two-tailed α=0.05, and a 10% dropout rate reserved, the required sample size was 215 patients per group, totaling 430 enrolled patients.

Treatment protocol

Surgical approaches were determined by attending senior orthopedic surgeons according to AO/OTA fracture classification, bone mineral density, patient age and preoperative mobility. For displaced femoral neck fractures in patients over 65 years, hemiarthroplasty or total hip arthroplasty was preferred; cannulated screw or dynamic hip screw internal fixation was adopted for nondisplaced lesions or younger patients. Intertrochanteric fractures were treated with proximal femoral nail antirotation or dynamic hip screw. Tibial plateau and tibiofibular fractures received plate-screw open reduction and internal fixation. Patellar fractures were managed with tension band wiring or partial/total patellectomy based on fracture displacement. Anesthesia method (general or regional) was determined by anesthesiologists according to American Society of Anesthesiologists (ASA) classification and patient willingness.

Nursing intervention

Routine nursing (control group): All patients in the control group received standardized conventional orthopedic nursing, covering six core contents: (1) Preoperative health education: explaining surgical procedures, postoperative complication risks and basic bedridden rehabilitation training to patients and family members; (2) Postoperative vital sign monitoring: four-hourly monitoring of blood pressure, heart rate and blood oxygen saturation within 72 hours postoperatively with timely reporting of abnormal indicators; (3) Incision care: routine dressing change, dynamic observation of incision exudation, redness and infection signs; (4) Basic rehabilitation guidance: assisted passive and active limb training and individualized progressive ambulation guidance; (5) Daily care and dietary intervention: assisted feeding and regular position adjustment, plus low-salt, low-fat high-protein dietary guidance; (6) Post-discharge follow-up: outpatient and telephone follow-up to monitor fracture healing and resolve rehabilitation-related questions.

Unaccompanied care model intervention (observation group): Patients in the observation group received full conventional nursing plus staged unaccompanied care delivered by fixed two-person teams consisting of one registered nurse and one certified nursing assistant throughout inpatient stay.

(1) Admission preparation stage: Attending physicians clarified service scope, workflow and clinical benefits of unaccompanied care to patients and guardians before informed consent signing. Nursing teams formulated individualized nursing plans based on baseline age, fracture type and preoperative activities of daily living (ADL) scores, completed personalized bed allocation, and implemented a triple-check procedure for patient identity, medical orders and nursing supplies to eliminate admission preparation errors.

(2) Perioperative inpatient nursing stage: ① Standardized daily basic care: Teams implemented regular position turning, perineal care, dietary assistance and defecation management stratified by ADL scores. A dual-person cross-rounding system was applied: hourly rounding for level 1 nursing patients and two-hourly rounding for level 2 nursing patients, with strict compliance with hospital three-check seven-match verification rules. ② Preoperative pre-rehabilitation: Five-dimensional pre-rehabilitation interventions were conducted, including individualized nutritional correction for hypoalbuminemia and anemia, bedridden muscle endurance training, perioperative psychological counseling, smoking and alcohol cessation intervention, and sleep cycle adjustment to improve surgical tolerance. ③ Intraoperative safety collaboration: Nursing staff cooperated with operating room teams to perform surgical pause-and-check safety verification, maintained intraoperative body position fixation and continuous vital sign monitoring to reduce surgical stress response. ④ Postoperative refined cardiac-oriented rehabilitation: A three-phase early rehabilitation protocol was initiated within 24 hours postoperatively, including in-bed muscle contraction training, bedside sitting training and graded off-bed walking. Vital signs were monitored hourly within 72 hours postoperatively, and rehabilitation

intensity was dynamically adjusted based on real-time myocardial biomarkers for early HF identification and intervention.

(3) Discharge transition and long-term follow-up stage: Targeted discharge education focused on home rehabilitation specifications, outpatient re-examination timing, underlying disease medication management and cardiac function self-monitoring. Individualized one-year follow-up schedules were established, including monthly telephone and WeChat follow-up and quarterly outpatient reviews. A triple inventory check for personal belongings, residual drugs and medical supplies was completed before discharge with standardized handover documentation for community follow-up staff.

Data collection

Baseline data: Patients' general demographic and clinical baseline data, including gender, age, body mass index (BMI), smoking and drinking histories, educational attainment, marital status, comorbidities (diabetes, hypertension, hyperlipidemia), fracture site, fracture type, cause of injury, ASA classification, time from injury to surgery, and duration of surgery, were extracted from the hospital electronic medical record system.

Lower limb motor function and ADL scores: Lower limb motor function and ADL were assessed with validated rating scales. Lower limb motor function was measured using the Fugl-Meyer Assessment (FMA) Scale [22]. The FMA contains separate upper and lower limb subscales; the lower limb subscale includes 17 items evaluating voluntary movement, synergy patterns, reflex activity and motor coordination, with a total score of 34 points. Each item was scored 0 (unable to perform), 1 (partial performance) or 2 (full performance), and higher scores indicate superior motor function. All assessments were conducted by two licensed rehabilitation therapists who completed standardized FMA training and achieved excellent inter-rater reliability (intraclass correlation coefficient, ICC > 0.90) prior to study initiation.

ADL capacity was evaluated using the Barthel Index [23], a 10-item scale covering feeding, bathing, dressing and other self-care behaviors, with total scores ranging from 0 to 100. Higher scores reflect greater functional independence.

Both scales were administered at three uniform time points: one day preoperatively (baseline), postoperative day 7, and postoperative month 6. All assessors were blinded to patient group allocation to eliminate evaluation bias.

Cardiac function-related indicators: Serum B-type natriuretic peptide (BNP) was detected at the three identical time points. Serum BNP concentrations were measured using a BioRad ZE5 cell analyzer with matched immunofluorescence kits. Transthoracic echocardiography was performed to record left ventricular ejection fraction (LVEF), left ventricular end-systolic diameter (LVESD) and left ventricular end-diastolic diameter (LVEDD) at each time point by the same attending echocardiographer.

Serum inflammatory marker detection: Five ml of peripheral venous blood was collected from each patient at the three predefined time points. Blood samples were centrifuged at 3,000 rpm for 15 minutes to isolate serum, which was stored at -80°C until batch testing. Target biomarkers including decoy receptor 3 (DcR3), Klotho and salusin-β were quantified via enzyme-linked immunosorbent assays. Detailed kit information was as follows: salusin-β (DLR-SALb-Hu, Wuxi Donglin Technology Development Co., Ltd.), Klotho (XG-H103839, Shanghai Xig Biology Technology Co., Ltd.), DcR3 (ab193697Aibo Anti (Shanghai) Trading Co., Ltd). All assays were processed on a Hitachi 7180 automatic biochemical analyzer following official kit protocols, and all specimens were tested in duplicate within the same assay batch.

Postoperative recovery indicators: Three primary postoperative recovery outcomes were recorded: time to affected limb swelling resolution, time to first off-bed ambulation, and length of hospital stay. Standardized definitions for each indicator were specified as follows: (1) Time to limb swelling resolution: the interval from surgery completion to the time when the circumference difference between the affected and contralateral limb was < 0.5 cm and remained stable for more than 24 consecutive hours; (2) Time to first off-bed ambulation: the interval from surgery completion to the patient's first independent standing and walking

Table 1. Comparison of baseline characteristics

Characteristic		Control group (n=215)	Observation group (n=215)	t/χ^2	*P*
Sex (n, %)	Male	133 (62.50)	138 (64.29)	2.494	0.617
	Female	82 (37.50)	77 (35.71)		
Age (years, mean ± SD)		71.60 ± 7.82	70.45 ± 8.21	1.487	0.138
BMI (kg/m^2, mean ± SD)		24.20 ± 2.80	24.60 ± 2.70	1.508	0.132
Smoking history (n, %)	Yes	87 (40.47)	91 (42.32)	0.153	0.695
	No	128 (59.53)	124 (57.67)		
Alcohol consumption history (n, %)	Yes	80 (37.20)	91 (42.32)	3.256	0.071
	No	135 (62.79)	124 (57.67)		
Educational level (n, %)	Primary school and below	52 (24.19)	70 (32.56)	3.969	0.137
	Junior/senior secondary	103 (47.91)	88 (40.93)		
	College degree or above	60 (27.91)	56 (26.05)		
Marital status (n, %)	Married	153 (71.62)	142 (66.05)	1.306	0.253
	Divorced or widowed	62 (28.83)	73 (33.95)		
Comorbid hypertension (n, %)	Yes	110 (51.16)	116 (53.95)	0.336	0.562
	No	105 (48.84)	99 (46.05)		
Comorbid diabetes (n, %)	Yes	90 (41.86)	101 (46.98)	1.139	0.286
	No	125 (58.14)	114 (53.02)		
Comorbid hyperlipidemia (n, %)	Yes	69 (32.09)	62 (28.84)	0.538	0.463
	No	146 (67.50)	153 (71.16)		
Fracture site(n, %)	Tibia and fibula	16 (7.50)	11 (5.00)	3.803	0.433
	Tibial plateau	16 (7.50)	22 (10.00)		
	Femoral neck	54 (25.00)	54 (25.00)		
	Greater trochanter	48 (22.50)	59 (27.50)		
	Patella	81 (37.50)	70 (32.50)		
Fracture type (n, %)	Open	74 (34.41)	59 (27.44)	2.449	0.118
	Closed	141 (65.58)	156 (72.56)		
Cause of injury (n, %)	Road traffic accident	113 (52.50)	109 (50.70)	1.089	0.896
	Fall from height	32 (15.00)	36 (16.74)		
	Blunt trauma	27 (12.50)	31 (14.42)		
	Fall injury	29 (13.49)	24 (11.16)		
	Other	14 (6.51)	15 (6.98)		
Time from injury to surgery (d, mean ± SD)		1.99 ± 0.32	2.01 ± 0.29	0.679	0.497
Duration of surgery (min, mean ± SD)		82.45 ± 18.60	83.38 ± 17.72	0.531	0.596

ASA classification (n, %)	Class I-II	172 (79.54)	163 (75.81)	0.858	0.354
	Class III-IV	43 (20.47)	52 (24.18)		
Surgical procedure (n, %)	Hemiarthroplasty/THA	87 (40.47)	84 (39.07)	0.601	0.896
	Internal fixation (DHS/PFNA/screws)	95 (44.19)	92 (42.79)		
	ORIF	22 (10.23)	26 (12.09)		
	Patellectomy/TBW	11 (5.12)	13 (6.05)		

Note: BMI, Body Mass Index. ASA, American Society of Anesthesiologists. THA, Total Hip Arthroplasty. DHS, Dynamic Hip Screw. PFNA, Proximal Femoral Nail Antirotation. ORIF, Open Reduction and Internal Fixation. TBW, Tension Band Wiring.

Table 2. Comparison of lower limb motor function and ADL scores

Indicator		Preoperatively	7 days postoperatively	6 months postoperatively	F	*P*
FMA (score, mean ± SD)	Control group (n=215)	17.28 ± 2.61	19.23 ± 2.88*	23.62 ± 2.55*,#	70.596	< 0.001
	Observation group (n=215)	16.84 ± 2.80	21.05 ± 2.75*	25.47 ± 2.88*,#	32.230	< 0.001
	t	1.685	6.702	7.052		
	P	0.096	< 0.001	< 0.001		
Barthel Index (score, mean ± SD)	Control group (n=215)	51.92 ± 8.72	59.66 ± 8.70*	71.62 ± 9.97*,#	422.454	< 0.001
	Observation group (n=215)	52.89 ± 8.18	64.07 ± 8.04*	77.63 ± 9.18*,#	701.322	< 0.001
	t	0.438	3.158	6.551		
	P	0.662	0.002	< 0.001		

Note: *$P < 0.05$, compared with preoperatively; #$P < 0.05$, compared with 7 days postoperatively. FMA, Fugl-Meyer Assessment.

Table 3. Comparison of cardiac function indicators

Indicator		Preoperatively	7 days postoperatively	6 months postoperatively	F	*P*
LVESD (mm, mean ± SD)	Control group (n=215)	53.10 ± 6.69	50.72 ± 5.38*	43.28 ± 4.73*,#	45.921	< 0.001
	Observation group (n=215)	52.45 ± 6.72	49.64 ± 5.26*	40.14 ± 5.84*,#	60.102	< 0.001
	t	1.005	1.749	6.126		
	P	0.315	0.081	< 0.001		
LVEF (%, mean ± SD)	Control group (n=215)	59.92 ± 4.28	62.35 ± 4.69*	68.37 ± 4.35*,#	58.760	< 0.001
	Observation group (n=215)	60.21 ± 4.53	65.21 ± 5.71*	71.27 ± 5.75*,#	92.019	< 0.001
	t	0.682	5.675	5.898		
	P	0.495	< 0.001	< 0.001		
LVEDD (mm, mean ± SD)	Control group (n=215)	62.42 ± 6.48	57.11 ± 6.34*	51.63 ± 6.13*,#	42.009	< 0.001
	Observation group (n=215)	63.08 ± 6.35	56.38 ± 5.88*	47.76 ± 5.74*,#	101.563	< 0.001
	t	1.067	2.934	6.757		
	P	0.287	0.004	< 0.001		
BNP (μg/L, mean ± SD)	Control group (n=215)	1.41 ± 0.21	1.35 ± 0.17*	1.02 ± 0.10*,#	196.202	< 0.001
	Observation group (n=215)	1.43 ± 0.24	1.24 ± 0.15*	0.97 ± 0.10*,#	326.912	< 0.001
	t	0.920	7.114	5.184		
	P	0.358	< 0.001	< 0.001		

Note: $^{*}P < 0.05$, compared with preoperatively; $^{\#}P < 0.05$, compared with 7 days postoperatively. LVEF, Left Ventricular Ejection Fraction. LVESD, Left Ventricular End-Systolic Diameter. LVEDD, Left Ventricular End-Diastolic Diameter. BNP, B-type Natriuretic Peptide.

Table 4. Comparison of serum inflammatory biomarkers

Indicator		Preoperatively	7 days postoperatively	6 months postoperatively	F	*P*
salusin-β (pg/mL, mean ± SD)	Control group (n=215)	382.89 ± 57.91	368.20 ± 55.30*	325.50 ± 42.10*,#	23.131	< 0.001
	Observation group (n=215)	378.45 ± 57.22	358.62 ± 58.43*	301.34 ± 48.35*,#	37.836	< 0.001
	t	0.800	1.746	5.526		
	P	0.423	0.082	< 0.001		
Klotho (pg/mL, mean ± SD)	Control group (n=215)	301.25 ± 34.28	324.68 ± 32.16*	348.41 ± 35.45*,#	34.168	< 0.001
	Observation group (n=215)	305.85 ± 33.15	332.74 ± 33.42*	355.78 ± 34.62*,#	32.976	< 0.001
	t	1.414	2.458	2.181		
	P	0.158	0.011	0.030		
DcR3 (ng/mL, mean ± SD)	Control group (n=215)	37.15 ± 4.78	41.47 ± 4.21*	43.65 ± 5.43*,#	28.644	< 0.001
	Observation group (n=215)	36.47 ± 4.69	42.46 ± 4.55*	46.36 ± 5.41*,#	82.520	< 0.001
	t	1.489	2.339	5.184		
	P	0.137	0.020	< 0.001		

Note: $^{*}P < 0.05$, compared with preoperatively; $^{\#}P < 0.05$, compared with 7 days postoperatively. DcR3, Decoy Receptor 3.

Table 5. Comparison of postoperative rehabilitation indicators

	Time to limb swelling resolution	Time to first off-bed ambulation	Length of hospital stay
Control group (n=215)	16.34 ± 3.17	4.68 ± 0.91	14.80 ± 2.32
Observation group (n=215)	13.40 ± 2.45	3.76 ± 0.85	11.45 ± 2.41
t	9.040	9.891	9.117
P	< 0.001	< 0.001	< 0.001

Table 6. Comparison of postoperative complication incidence (n, %)

	Lower limb soft tissue infection	DVT	Pressure injuries	HF	Total
Control group (n=215)	11 (5.12)	14 (6.51)	13 (6.05)	34 (15.81)	72 (33.49)
Observation group (n=215)	7 (3.26)	10 (4.65)	6 (2.79)	23 (10.70)	46 (21.40)
χ^2					7.895
P					0.005

Note: HF, Heart Failure. DVT, Deep Vein Thrombosis.

of no fewer than five steps with walker assistance; (3) Length of hospital stay: the total inpatient days from admission to formal discharge.

Postoperative complications: Postoperative complications including lower limb soft tissue infection, DVT, pressure injuries and HF were documented throughout inpatient stay and the subsequent 12-month follow-up. Individual complication incidence and overall total complication rates were calculated for both groups.

Statistical analysis

All statistical analyses were performed using R 4.5.2 software. Missing data were processed through multiple imputation. The Shapiro-Wilk test was used to test the normality of continuous variables. Normally distributed continuous data were expressed as mean ± standard deviation; independent samples t-tests were used for inter-group comparisons, and paired samples t-tests for paired intra-group comparisons. Non-normally distributed continuous data were presented as median (interquartile range), with the Mann-Whitney U test for inter-group comparisons. Categorical data were summarized as counts (percentages) [n (%)], and compared using the chi-square test or Fisher's exact test as appropriate. Repeated-measures analysis of variance was adopted for within-subject comparisons across multiple time points.

For HF risk prediction: postoperative HF was defined as the binary dependent variable (0 = no HF, 1 = HF occurrence). Variables with $P < 0.05$ by univariate analysis were included in multivariate logistic regression to screen independent HF predictors. A predictive nomogram was constructed based on regression results. Model performance was assessed by receiver operating characteristic (ROC) curves; calibration degree was verified by calibration plots, and clinical utility was evaluated through decision curve analysis (DCA). Internal validation was conducted using 1000 bootstrap resamples. SHAP analysis was applied to interpret the regression model output. All statistical tests were two-tailed, and $P < 0.05$ was significant.

Results

Comparison of baseline characteristics

No significant inter-group differences were observed in sex, age, BMI, smoking/drinking history, educational attainment, marital status, chronic comorbidities, fracture characteristics, time from injury to surgery, duration of surgery, ASA classification or surgical procedure (all $P > 0.05$) (**Table 1**).

Comparison of lower limb motor function and ADL scores

FMA and Barthel Index scores were comparable between the two groups at baseline (both

Table 7. Univariate analysis of postoperative HF influencing factors

Characteristic		HF group (n=34)	Non-HF group (n=181)	t/χ^2	*P*
Sex (n, %)	Male	18 (52.94)	115 (63.54)	1.362	0.243
	Female	16 (47.06)	66 (36.46)		
Age (years, mean ± SD)		75.60 ± 6.82	73.16 ± 8.22	3.350	< 0.001
BMI (kg/m^2, mean ± SD)		23.45 ± 3.71	24.14 ± 3.47	1.052	0.294
Smoking history (n, %)	Yes	15 (40.47)	76 (42.32)	0.053	0.818
	No	19 (59.53)	105 (57.67)		
Alcohol consumption history (n, %)	Yes	18 (52.94)	75 (41.43)	1.543	0.214
	No	16 (47.06)	106 (58.57)		
Educational level (n, %)	Primary school and below	11 (32.35)	58 (32.04)	0.107	0.948
	Junior/senior secondary	13 (38.24)	74 (40.88)		
	College degree or above	10 (29.41)	49 (27.07)		
Marital status (n, %)	Married	23 (67.65)	122 (67.40)	0.000	0.978
	Divorced or widowed	11 (32.35)	59 (32.60)		
Comorbid hypertension (n, %)	Yes	14 (41.18)	86 (53.03)	0.462	0.497
	No	20 (58.82)	95 (52.49)		
Comorbid diabetes (n, %)	Yes	19 (58.88)	71 (39.23)	3.263	0.071
	No	15 (44.12)	110 (60.77)		
Comorbid hyperlipidemia (n, %)	Yes	10 (29.41)	59 (32.60)	0.133	0.715
	No	24 (70.59)	122 (67.40)		
Fracture site(n, %)	Tibia and fibula	3 (8.82)	13 (7.18)	1.505	0.826
	Tibial plateau	4 (11.76)	12 (6.63)		
	Femoral neck	9 (26.47)	45 (24.86)		
	Greater trochanter	7 (20.59)	41 (22.65)		
	Patella	11 (32.35)	70 (38.67)		
Fracture type (n, %)	Open	8 (23.53)	66 (36.46)	2.122	0.145
	Closed	26 (76.47)	115 (63.54)		
Cause of injury (n, %)	Road traffic accident	18 (52.94)	95 (52.49)	0.091	0.998
	Fall from height	5 (14.71)	27 (14.92)		
	Blunt trauma	4 (11.76)	23 (12.71)		
	Fall injury	5 (14.71)	24 (13.26)		
	Other	2 (5.88)	12 (6.63)		
Time from injury to surgery (d, mean ± SD)		2.18 ± 0.30	1.88 ± 0.27	5.839	< 0.001
Duration of surgery (min, mean ± SD)		85.94 ± 21.64	76.47 ± 18.72	2.639	0.009

ASA classification (n, %)	Class I-II	14 (41.18)	158 (87.29)	38.046	< 0.001
	Class III-IV	20 (58.82)	23 (12.71)		
FMA (score, mean ± SD)		16.83 ± 2.58	17.08 ± 2.67	0.504	0.615
Barthel Index (score, mean ± SD)		50.21 ± 9.36	51.76 ± 9.43	0.880	0.379
LVESD (mm, mean ± SD)		54.48 ± 6.78	53.17 ± 7.12	0.992	0.333
LVEF (%, mean ± SD)		58.63 ± 6.01	60.22 ± 6.58	1.310	0.192
LVEDD (mm, mean ± SD)		61.35 ± 6.15	60.47 ± 6.81	0.701	0.484
BNP (μg/L, mean ± SD)		1.52 ± 0.31	1.38 ± 0.24	2.971	0.003
salusin-β (pg/mL, mean ± SD)		384.69 ± 58.72	364.47 ± 46.38	1.789	0.025
Klotho (pg/mL, mean ± SD)		301.41 ± 35.23	314.70 ± 31.64	2.207	0.028
DcR3 (ng/mL, mean ± SD)		35.82 ± 4.61	37.04 ± 4.57	1.426	0.155

Note: BMI, Body Mass Index. ASA, American Society of Anesthesiologists. FMA, Fugl-Meyer Assessment. LVEF, Left Ventricular Ejection Fraction. LVESD, Left Ventricular End-Systolic Diameter. LVEDD, Left Ventricular End-Diastolic Diameter. BNP, B-type Natriuretic Peptide. DcR3, Decoy Receptor 3.

Table 8. Multicollinearity analysis

Characteristic	VIF	Tolerance
Age	1.842	0.513
Time from injury to surgery	1.310	0.726
Duration of surgery	1.678	0.582
LVEF	1.275	0.744
ASA classification	1.625	0.818
BNP	1.474	0.759
salusin-β	1.842	0.513
Klotho	1.226	0.773

Note: LVEF, Left Ventricular Ejection Fraction. BNP, B-Type Natriuretic Peptide. VIF, Variance Inflation Factor. ASA, American Society of Anesthesiologists.

P > 0.05). At postoperative day 7 and month 6, the observation group yielded significantly higher FMA and Barthel Index scores than the control group (*P* < 0.001 and *P* < 0.05, respectively). Intra-group analyses showed that both groups achieved progressive improvements in FMA and Barthel Index scores over the three time points, with scores at postoperative day 7 and month 6 significantly higher than baseline, and month 6 scores significantly higher than postoperative day 7 scores (all *P* < 0.05) (**Table 2**).

Comparison of cardiac function indicators

At postoperative day 7, the observation group had higher LVEF and lower LVEDD and BNP levels than the control group (*P* < 0.001, *P* < 0.05), while LVESD showed no inter-group difference (*P* > 0.05). At postoperative month 6, the observation group exhibited superior LVESD, LVEDD, LVEF, and BNP outcomes (all *P* < 0.001). Intra-group comparisons demonstrated that both groups had improved cardiac function at postoperative day 7 relative to baseline, with further functional improvements at postoperative month 6 (all *P* < 0.05) (**Table 3**).

Comparison of serum inflammatory biomarkers

All serum biomarker levels were balanced between groups at baseline (all *P* > 0.05). At postoperative day 7, there was no significant difference in salusin-β levels between the two groups (*P* > 0.05), while the observation group had significantly higher Klotho and DcR3 levels (both *P* < 0.05). At postoperative month 6, the observation group had lower salusin-β and persistently higher Klotho and DcR3 levels (all *P* < 0.05). Intra-group analyses revealed that salusin-β gradually decreased while Klotho and DcR3 gradually increased over postoperative time in both groups (all *P* < 0.05) (**Table 4**).

Comparison of postoperative rehabilitation indicators

The observation group had significantly shorter time to limb swelling resolution, earlier time to first off-bed ambulation, and shorter length of hospital stay than the control group (all *P* < 0.05) (**Table 5**).

Comparison of postoperative complication incidence

The overall complication rate was 21.40% (46/215) in the observation group versus 33.49% (72/215) in the control group (χ^2= 7.895, *P*=0.005). The observation group had lower individual incidences of pressure injuries (2.79% vs. 6.05%), DVT (4.65% vs. 6.51%), lower limb infection (3.26% vs. 5.12%) and postoperative HF (10.70% vs. 15.81%) (**Table 6**).

Univariate analysis of postoperative HF influencing factors

The control group was subdivided into HF (n=34) and non-HF (n=181) subgroups based on postoperative HF occurrence. Univariate analysis identified age, time from injury to surgery, duration of surgery, preoperative LVEF, ASA classification, preoperative BNP, salusin-β and Klotho as factors associated with postoperative HF (all *P* < 0.05) (**Table 7**).

Multicollinearity analysis

Multicollinearity was defined as variance inflation factor (VIF) > 5 or tolerance < 0.2. All included variables met VIF < 5 and tolerance > 0.2, indicating no multicollinearity. Thus, multivariate logistic regression was performed sequentially (**Table 8**).

Multivariate logistic regression and ROC cut-off analysis

Multivariate logistic regression confirmed that advanced age, ASA III-IV classification, elevated preoperative BNP, and reduced preopera-

Table 9. Multivariate logistic regression and ROC cut-off analysis

Characteristic	β	SE	Wald χ^2	*P*	OR	95% CI
Age	0.097	0.027	12.675	0.001	1.102	1.045-1.163
Time from injury to surgery	0.488	0.254	3.709	0.054	3.473	1.360-5.227
Duration of surgery	0.028	0.009	9.540	0.112	1.079	1.002-1.153
LVEF	-0.563	0.308	3.352	0.067	0.694	0.625-0.783
ASA classification	0.951	0.289	10.828	< 0.001	2.013	1.259-3.047
BNP	0.057	0.017	11.242	< 0.001	1.057	1.018-1.129
salusin-β	0.015	0.012	1.520	0.217	1.014	1.006-1.021
Klotho	-0.012	0.004	8.273	0.004	0.991	0.898-0.997

Note: LVEF, Left Ventricular Ejection Fraction. BNP, B-type Natriuretic Peptide. ASA, American Society of Anesthesiologists.

Table 10. Predictive performance of risk factors for postoperative HF

Characteristic	AUC	95% CI	Sensitivity	Specificity	Youden index	Cut-off value
Age	0.696	0.605-0.787	0.497	0.824	0.321	52.50 (years)
ASA classification	0.731	0.643-0.818	0.873	0.588	0.461	/
BNP	0.809	0.737-0.881	0.757	0.735	0.492	1.535 (μg/L)
Klotho	0.834	0.775-0.893	0.608	0.941	0.549	307.85 (pg/mL)

Note: BNP, B-type natriuretic peptide. ASA, American Society of Anesthesiologists.

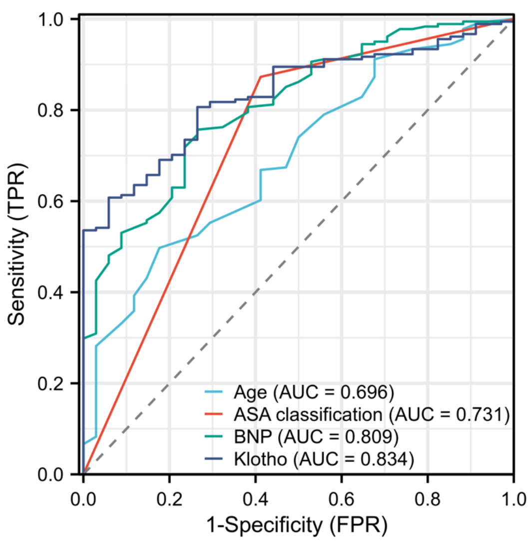

Figure 1. ROC curves for the prediction of variables associated with postoperative HF in patients. BNP, B-type Natriuretic Peptide. ASA, American Society of Anesthesiologists.

tive Klotho were independent predictors of postoperative HF (**Table 9**). ROC curve analysis was performed to screen the optimal cut-off points of continuous variables based on the maximum Youden's index. The derived critical values were 52.50 years for age, 1535.00 pg/mL for BNP, and 307.85 pg/mL for Klotho (**Table 10**; **Figure 1**).

Nomogram construction, validation, and calibration

A predictive nomogram was established using the four independent predictors. The regression formula was: Logit (HF probability) = 3.386 + 0.097 × age + 0.951 × (ASA III-IV) + 0.057 × (BNP > 1.535 μg/L) - 0.012 × (Klotho > 307.85 pg/mL). The nomogram scoring system ranged from 0 to 160 points, corresponding to a postoperative HF predicted probability of 1% to 90% (**Figure 2**).

The original model yielded an area under the curve (AUC) of 0.879 (95% CI: 0.817-0.941) (**Figure 3A**). After 1000 bootstrap internal validation, the corrected AUC was 0.864 (95% CI: 0.776-0.952). The calibration curve showed high consistency between predicted and actual HF risks (**Figure 3B**). DCA verified positive net clinical benefit of the model within a reasonable high-risk threshold (**Figure 3C**).

SHAP interpretability analysis

Feature importance ranking based on mean absolute Shapley values showed Klotho exerted the strongest predictive contribution, followed by ASA classification, BNP and age (**Figure 4A**). Single-sample waterfall plots illustrate variable contribution directions: elevated

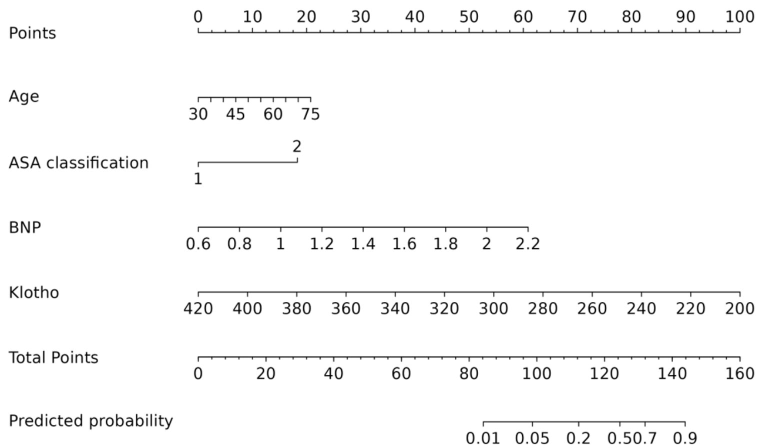

Figure 2. Column chart for predicting postoperative HF risk in patients. In the ASA classification, 1 corresponds to grades I-II, and 2 corresponds to grades III-IV. BNP, B-type Natriuretic Peptide. ASA, American Society of Anesthesiologists.

age, high ASA classification, increased BNP and decreased Klotho all increased individual HF risk (**Figure 4B**). Shap scatter plots further verify dose-response relationships: lower Klotho levels, higher BNP levels and ASA III-IV status correlated with elevated HF risk, while advanced age showed weak positive correlation with HF risk (**Figure 4C**).

Discussion

This study demonstrated that unaccompanied care based on routine orthopedic nursing improved postoperative lower limb motor function, ADL capacity, cardiac function, and serum inflammatory biomarker profiles, and reduced overall postoperative complication and HF risks in elderly lower limb fracture patients. Independent predictors of postoperative HF identified from control group data included age, ASA classification, preoperative BNP and Klotho, and the constructed nomogram presented reliable predictive performance.

Patients receiving unaccompanied care obtained better FMA and Barthel Index outcomes, which aligned with findings from Chen et al. [9]. Shorter hospital stay and faster limb swelling resolution were also observed in the observation group. Unlike conventional nursing relying on untrained family caregivers, standardized two-person nursing teams delivered continuous perioperative care. Preoperative five-element pre-rehabilitation corrected malnutrition, improved physical endurance and relieved surgical anxiety. Postoperative staged early rehabilitation within 24 hours after surgery promoted venous backflow and muscle function recovery, while real-time cardiac monitoring prevented premature rehabilitation-induced fracture displacement and excessive myocardial oxygen consumption [24, 25].

Superior cardiac function indicators in the observation group were attributed to two core mechanisms. First, hourly postoperative cardiac monitoring facilitated early identification of asymptomatic myocardial strain and prompt anti-HF intervention. Second, individualized rehabilitation intensity adjustment avoided excessive cardiac load, and standardized chronic disease medication management mitigated cardiovascular damage from underlying hypertension and diabetes. LVEF, LVESD and LVEDD reflect left ventricular systolic and diastolic function, while BNP is a validated biomarker for myocardial wall stress and HF progression [26, 27].

Altered serum biomarker levels in the observation group reflected alleviated surgical inflammatory stress. Salusin-β mediates myocardial diastolic dysfunction [28], while Klotho protects vascular endothelium through anti-oxidative and anti-inflammatory pathways [29], and DcR3 suppresses pro-inflammatory cytokine release [30]. Preoperative nutritional optimization and early mobilization in unaccompanied care relieved systemic inflammation, lowered cardiovascular inflammatory injury, and further reduced HF susceptibility [31].

The four independent HF predictors identified in this study were partially consistent with Tian et al. [21]. Advanced age increases HF risk due to age-related myocardial fibrosis and impaired hemodynamic stress tolerance [32, 33]. Higher ASA classification indicates poorer baseline physical reserve, which increases perioperative hemodynamic instability and cardiac complication risk [34, 35]. Elevated preoperative BNP reflects subclinical myocardial dysfunction, a well-established HF risk indicator [36]. By contrast, Klotho acts as a protective factor:

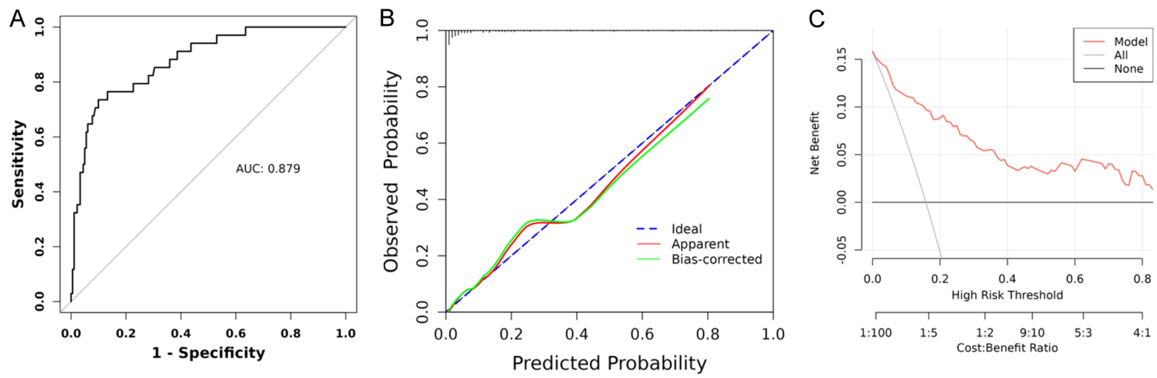

Figure 3. Scatter plots for the predictive model of postoperative HF. A. ROC curve for predicting postoperative HF based on the nomogram. B. Calibration curve for predicting postoperative HF based on the nomogram. C. Decision-making curve for predicting postoperative HF based on the nomogram.

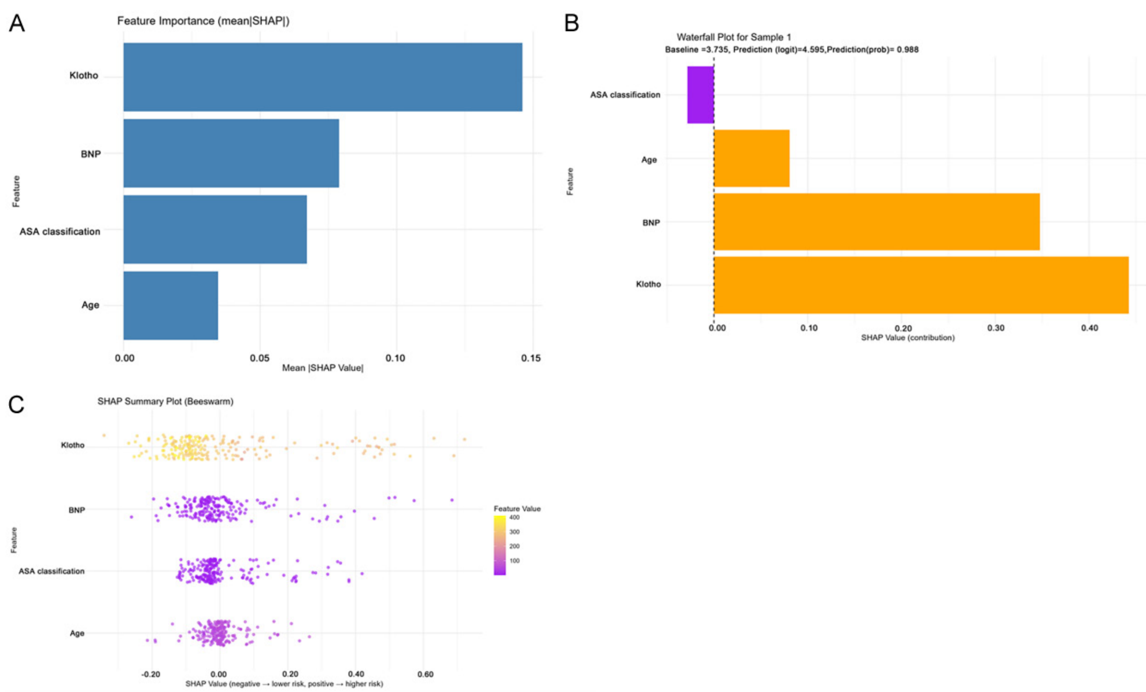

Figure 4. Model interpretability analysis based on the Shap method. A. Feature Importance Bar Chart. This chart ranks the features based on their average absolute SHAP values (mean (|SHAP value|)). The larger the value, the greater the overall contribution of the feature to the model's prediction. The chart shows the importance ranking of four features: Klotho, ASA classification, BNP, and Age. B. Single Sample Shap Waterfall Chart. This chart illustrates the decomposition process of the prediction value for the first sample. The baseline prediction value is 3.735 and the actual predicted probability is 0.988. Each bar graph represents the contribution of a certain feature: the orange bar indicates that this feature causes the prediction value to shift in the negative direction (reducing the risk of HF), while the yellow bar indicates a positive shift (increasing the risk of HF). The numbers marked on the bars represent the Shap values of each feature, reflecting their specific contribution to the final prediction. C. Shap Summary Plot (Honeycomb Chart). This chart presents the distribution of Shap values for each feature across all samples. The X-axis represents the Shap values, with negative values indicating a reduction in the prediction result (reducing the risk of HF), and positive values indicating an increase in the prediction result (increasing the risk of HF). The Y-axis is sorted by feature importance. The color ranges from purple to yellow, representing the trend of feature values changing from low to high, allowing for an intuitive presentation of the correlation between feature strength and Shap values. For example, for Klotho, the low values (purple) are mainly concentrated in the positive Shap value area, suggesting that the lower the Klotho level, the higher the risk of HF. BNP, B-type Natriuretic Peptide. ASA, American Society of Anesthesiologists.

reduced Klotho expression weakens cardiovascular stress resistance, amplifying surgical inflammatory damage and HF risk.

The nomogram achieved excellent discrimination, calibration and clinical net benefit. The SHAP analysis resolved the black-box limitation of traditional logistic regression by quantifying variable contribution magnitude and direction. This improves clinical operability for individualized HF risk stratification.

Limitations

This was a single-center retrospective study with non-randomized time-based grouping. Group allocation by calendar year may introduce temporal confounding bias and selection bias. Future multicenter prospective randomized controlled trials are required to validate the findings. In addition, only circulating protein biomarkers were included in risk factor analysis; incorporating genetic and echocardiographic strain indicators may further optimize prediction accuracy. Long-term follow-up exceeding 12 months is also needed to verify sustained cardiac outcomes.

Conclusion

Unaccompanied perioperative nursing improveed postoperative limb functional recovery, cardiac function and inflammatory homeostasis, shortened rehabilitation duration, and reduced complication risks for elderly lower limb fracture patients. Age, ASA classification, preoperative BNP and Klotho were independent predictors of postoperative HF. The validated nomogram provided reliable individualized HF risk stratification, supporting targeted early preventive intervention in clinical geriatric orthopedic practice.

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Disclosure of conflict of interest

None.

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References

[1] Abedi A, Chu CH and Khan SS. Multimodal sensor dataset for monitoring older adults post lower limb fractures in community settings. Sci Data 2025; 12: 733.
[2] Qi B, Kong X, Meng C and Li Q. Analysis of the impact of underlying diseases in the elderly on postoperative re-fractures after osteoporotic compression fractures. J Orthop Surg Res 2024; 19: 556.
[3] Zhang N, Wang T, Gu R and Gu M. Psychological safety and its influencing factors among elderly patients following traumatic fracture surgery: a cross-sectional study. BMC Geriatr 2025; 25: 1062.
[4] Yu Q, Fu M, Hou Z and Wang Z. Developing a prediction model for preoperative acute heart failure in elderly hip fracture patients: a retrospective analysis. BMC Musculoskelet Disord 2024; 25: 736.
[5] Riaz MH, Riaz J, Mahmood A, Tariq M, Sahar N, Ali RS, Ahmad N, Irshad S, Ahmad MH, Arshad H and Khan TM. Risk factors of postoperative acute heart failure in elderly patients after hip fracture surgery. Cureus 2024; 16: e58967.
[6] Cha YH, Ha YC, Ryu HJ, Lee YK, Park SH, Lee KJ and Koo KH. Effect of heart failure on postoperative short and long-term mortality in elderly patients with hip fracture. Injury 2020; 51: 694-698.
[7] Netzer S, Ruch C, Ivanova S, Limacher A, Meyer L and Eggimann AK. Difference in discharge disposition, adherence to clinical care standards and functional outcomes of older hip fracture patients receiving an orthogeriatric model of care versus routine care. J Orthop Surg Res 2025; 20: 993.
[8] Millar NA, Hunter KF, Dahlke S, Tate K, Al-agadan IJ and Hoben M. The participation of older persons in the adoption of age-friendly care models in hospital settings: a scoping review. Nurs Health Sci 2026; 28: e70274.
[9] Chen X, Huang Y, Chen F, Jiang X, Lin D and Lin F. The incidence and risk factors of perioperative delirium in elderly patients with hip fracture under the Unaccompanied-Care model. J Orthop Surg Res 2025; 20: 693.
[10] Wang Y, Wang Z, Chen B, Chen B, Fang R, Zeng H, Peng J, Gao Y and Hao L. Global epidemiology of lower limb fractures: trends, burden, and projections from the GBD 2021 study. Bone 2025; 193: 117420.
[11] Chinese Society of Cardiology, Chinese Medical Association; Chinese College of Cardiovas-

cular Physician; Chinese Heart Failure Association of Chinese Medical Doctor Association; Editorial Board of Chinese Journal of Cardiology. Chinese guidelines for the diagnosis and treatment of heart failure 2024. Zhonghua Xin Xue Guan Bing Za Zhi 2024; 52: 235-275.
[12] Chinese Nutrition Society Obesity Prevention and Control Section; Chinese Nutrition Society Clinical Nutrition Section; Chinese Preventive Medicine Association Behavioral Health Section; Chinese Preventive Medicine Association Sports and Health Section. Expert consensus on obesity prevention and treatment in China. Zhonghua Liu Xing Bing Xue Za Zhi 2022; 43: 609-626.
[13] Luca MD and Ramirez ML. A pandemic treaty: learning from the framework convention on tobacco control. Health Secur 2023; 21: 105-112.
[14] Association CM, Press CMA, Gastroenterology CMABo, Practice CMABoG, Association) EBotC-JoGPCM and Diseases EGftDoPCGfG. Guidelines for the primary care management of alcoholic liver disease (2019). Chin J of General Practice 2020; 19: 990-996.
[15] Committee CGftPaToHR, Alliance H, Care HBot-CAfIEoMaH, Society HBotCG, Care HBotCAoGH, Society CS and Centre for the Prevention and Control of Chronic Non-communicable Diseases CCfDCaP. Chinese guidelines for the prevention and treatment of hypertension (2024 revised edition). Chin J Hypertens 2024; 32: 603-700.
[16] Joint Committee on the Chinese Guidelines for Lipid Management. Chinese guidelines for lipid management (2023). Zhonghua Xin Xue Guan Bing Za Zhi 2023; 51: 221-255.
[17] Association DBotCM. Chinese guidelines for the prevention and treatment of type 2 diabetes (2020 edition). Chin J of Diabetes 2021; 13: 315-409.
[18] Cohen N, Kyin C, Norman D, Peskin B, Ghrayeb N, Perets I, Sachs O, Awad B, Ron I and Shapira J. Risk factors for postoperative infection in patients after pilon fracture fixation. J Foot Ankle Surg 2025; 64: 397-401.
[19] Middeldorp S, Nieuwlaat R, Baumann Kreuziger L, Coppens M, Houghton D, James AH, Lang E, Moll S, Myers T, Bhatt M, Chai-Adisaksopha C, Colunga-Lozano LE, Karam SG, Zhang Y, Wiercioch W, Schünemann HJ and Iorio A. American Society of Hematology 2023 guidelines for management of venous thromboembolism: thrombophilia testing. Blood Adv 2023; 7: 7101-7138.
[20] Velozo BC, Hong MV, Bernardo LC, E Castro MCN, Contreras-Ruiz J and Abbade LPF. Pressure injury: update on general concepts, clinical aspects, and laboratory findings - Part I. An Bras Dermatol 2025; 100: 501187.
[21] Tian M, Li W, Wang Y, Tian Y, Zhang K, Li X and Zhu Y. Risk factors for perioperative acute heart failure in older hip fracture patients and establishment of a nomogram predictive model. J Orthop Surg Res 2023; 18: 347.
[22] Gladstone DJ, Danells CJ and Black SE. The fugl-meyer assessment of motor recovery after stroke: a critical review of its measurement properties. Neurorehabil Neural Repair 2002; 16: 232-240.
[23] Mahoney FI and Barthel DW. Functional evaluation: the barthel index. Md State Med J 1965; 14: 61-65.
[24] Miao J, Guimin W and Li L. Impact of a standardized operating room nursing process on postoperative recovery in patients with fractures. Asian J Surg 2025; 48: 5561-5562.
[25] Ma Y, Zhang Y, Tang Y, Wu F, Wang S, Zeng J, Yang Y, Liu Q, Li R and Tuo Y. Barriers to early rehabilitation and support needs among elderly hip fracture patients with kinesiophobia: a qualitative study. Disabil Rehabil 2026; 48: 187-196.
[26] Çelik A, Öztürk GZ, Çavuşoğlu Y, Ardıç C, Nalbantgil S, Arıca S, Temizhan A, Altay H, Yılmaz MB, Özsarı H and Ural D. Guideline for the use of natriuretic peptides in the early diagnosis and management of heart failure in primary care (joint consensus report by the Eurasian society of heart failure and the Turkish association of family medicine). Balkan Med J 2025; 42: 94-107.
[27] Wang QC, Li JY, Ni XS, Zhao WW, Wang XC and Wang LC. Impact of walking and respiratory training on cardiopulmonary function and activity endurance in patients with chronic heart failure. Clin Cardiol 2025; 48: e70123.
[28] Chen MX, Deng BY, Liu ST, Wang ZB and Wang SZ. Salusins: advance in cardiovascular disease research. J Pharm Pharmacol 2023; 75: 363-369.
[29] Zavvari Oskuye Z, Mehri K, Khalilpour J, Nemati S, Hosseini L, Bafadam S, Abdollahzade N and Badalzadeh R. Klotho in age-related cardiovascular diseases: insights into mitochondrial dysfunction and cell death. Int J Cardiol Heart Vasc 2025; 57: 101629.
[30] Uysal S, Toker A, Türkmen K and Keskin S. The role of decoy receptor 3 in inflammation and atherosclerosis in patients with chronic kidney disease and renal transplant patients. Nefrologia (Engl Ed) 2023; 43: 344-350.
[31] Ni M, Sun T, Zhang T, Jin J and Song Y. Quantitative initial safety range of early passive rehabilitation after ankle fracture surgery. Injury 2022; 53: 2281-2286.

[32] Zhang F, Deng S, Zhang J, Xu W, Xian D, Wang Y, Zhao Q, Liu Y, Zhu X, Peng M and Zhang L. Causality between heart failure and epigenetic age: a bidirectional Mendelian randomization study. ESC Heart Fail 2023; 10: 2903-2913.
[33] Zhao W, Yan Q and Mou C. Physical activity and cardiovascular-metabolic disease risk across cardiovascular-kidney-metabolic syndrome stages: a population-based cohort study. BMC Cardiovasc Disord 2025; 25: 748.
[34] Liu Y, Fu Y, Hao J, Zhang F and Liu H. Construction and validation of a nomogram for predicting in-hospital postoperative heart failure in elderly patients with hip fracture. Beijing Da Xue Xue Bao Yi Xue Ban 2024; 56: 874-883.
[35] Weinberg L, Ou Yang B, Cosic L, Klink S, Le P, Li JK, Koshy AN, Jones D, Bellomo R, Tan CO and Lee DK. Factors influencing early and long-term survival following hip fracture among nonagenarians. J Orthop Surg Res 2021; 16: 653.
[36] Durak-Nalbantic A, Begic E, Begic A, Dzubur A, Lepara O, Baljic R, Hamzic-Mehmedbasic A, Rebic D, Hodzic E, Halimic M and Badnjevic A. Biomarkers and their combination in a prediction of decompensation after an index hospitalization for acute heart failure. J Family Med Prim Care 2023; 12: 1158-1164.