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Original Article

Early rehabilitation nursing prevents postoperative DVT and promotes limb function recovery in patients with traumatic fracture

Lanlan Li[1], Yuanyuan Huang[1], Jing He[1], Qinghua Zheng[2]

[1]Department of Orthopedics and Traumatology, Hanzhong Hospital of TCM, No. 8 Dongchang Street, Dahekan Town, Nanzheng District, Hanzhong 723102, Shaanxi, China; [2]Department of Intervention and Vascular Surgery, Hanzhong Central Hospital, No. 557, Middle Section of Laodong West Road, Hantai District, Hanzhong 723000, Shaanxi, China

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Abstract: Objective: To evaluate the effectiveness of early rehabilitation nursing in preventing deep vein thrombosis (DVT) and promoting functional recovery in patients with lower limb traumatic fractures, and to identify independent risk factors for DVT. Methods: A retrospective cohort study was conducted, including 162 patients treated for lower limb traumatic fractures at Hanzhong Hospital of TCM from January 2022 to December 2023. The control group (n=78) received conventional nursing care prior to January 2023, while the observation group (n=84) received early rehabilitation nursing after January 2023. The control group received routine care, including preoperative education, intraoperative temperature monitoring, and postoperative vital signs monitoring, along with basic guidance for lower limb movement. The observation group received additional personalized early rehabilitation interventions, including tailored preoperative education, psychological support, optimized anesthesia management, advanced postoperative pain control, and progressive lower limb functional exercises. Collected data included baseline characteristics, rehabilitation indicators (e.g., catheter retention time, time to first feeding, and time to first ambulation), postoperative complications, and assessments of pain (Visual Analogue Scale, VAS), quality of life (World Health Organization Quality of Life [WHOQOL]-BREF), and lower limb functional recovery (Fugl-Meyer lower limb function score). Multivariate logistic regression was performed to identify independent risk factors for DVT. Results: There were no significant differences in baseline characteristics between the control and observation groups (all P>0.05). The observation group exhibited significantly lower VAS scores at 7 days postoperatively (P<0.001), along with significantly higher WHOQOL-BREF scores across physical, psychological, social, and environmental domains, and significantly higher Fugl-Meyer lower limb function scores one month after the intervention (P<0.001). Rehabilitation indicators, such as catheter retention time, time to first feeding, time to first ambulation, initiation of exercises, and hospital stay duration, were all shorter in the observation group compared to the control group (all P<0.05). The incidence of DVT was significantly lower in the observation group (P=0.002). Multivariate logistic regression analysis identified nursing intervention (OR=3.086, P=0.024), age ≥60 years (OR=2.589, P=0.043), body mass index (BMI) of 21-25 kg/m^2 (OR=2.444, P=0.037), and catheter retention time ≥19.5 hours (OR=2.401, P=0.061) as independent risk factors for DVT. Conclusion: Early rehabilitation nursing is highly effective in preventing DVT and enhancing lower limb functional recovery in patients with traumatic fracture. It significantly reduces rehabilitation time and improves quality of life. Independent risk factors for DVT include nursing protocol, advanced age, BMI, and prolonged catheter retention time, all of which should be prioritized in clinical care.

Keywords: Early rehabilitation nursing, traumatic fractures, postoperative DVT, limb function

Introduction

Traumatic fractures, particularly in the lower limbs, are common in orthopedics due to high-energy injuries, often require surgical intervention [1]. Postoperative recovery significantly influences the prognosis and quality of life for these patients. Among the most common complications, deep vein thrombosis (DVT) presents a major challenge, as it not only impedes recovery but also extends hospital stay, increases healthcare costs, and may, in severe cases, be life-threatening [2]. Patients with lower limb fractures are especially prone to DVT due to

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hemodynamic changes from surgical trauma and prolonged immobility [3]. The risk is further heightened in older or frail individuals, highlighting the need for effective DVT prevention strategies and approaches to accelerate functional recovery.

With advancements in clinical nursing, early rehabilitation nursing has gained considerable attention [4]. This approach encourages patients to engage in light physical activity soon after surgery, promoting blood circulation and reducing the risk of venous thrombosis [5]. The core principle involves enhancing muscle contractions and venous blood return through gentle exercises, thus alleviating venous stasis. Additionally, early rehabilitation alleviates pain, boosts patient motivation for recovery, and accelerates functional restoration [6, 7]. Despite its potential, research on early rehabilitation nursing for DVT prevention in postoperative lower limb fractures remains limited and fragmented, particularly in China, where standardized care protocols and intervention strategies are still developing.

The functional recovery of patients with lower limb fractures is critical during postoperative rehabilitation [8]. Improved function not only enhances self-care ability but also contributes to a better quality of life [9]. The Fugl-Meyer Assessment for lower limb function is a widely recognized tool for objectively evaluating the effect of rehabilitation nursing on functional recovery [10]. Early rehabilitation nursing, incorporating both active and passive exercises, strengthens lower limb muscles, improves joint flexibility, and reduces the risk of postoperative complications such as muscle atrophy and joint stiffness [11]. In contrast, traditional nursing models often delay mobilization, inadvertently contributing to muscle deconditioning and prolonged recovery times [12]. Early rehabilitation thus represents a crucial intervention for improving postoperative quality of life.

Recent studies have examined the application of early rehabilitation nursing in traumatic fractures, particularly for lower limb injuries, emphasizing its potential to reduce hospital stays and postoperative complications. However, many of these studies rely on small sample sizes or isolated interventions, limiting their broader applicability. Therefore, a systematic analysis of early rehabilitation nursing's effects on DVT prevention and functional recovery in lower limb traumatic fractures is of great clinical value. This study aims to fill these gaps by providing evidence to optimize nursing care, improve recovery outcomes, and help patients return to normal life.

This study evaluates the efficacy of early rehabilitation nursing in preventing DVT and promoting lower limb functional recovery through a retrospective analysis. Unlike previous studies with small cohorts or single interventions, this research integrates a comprehensive early rehabilitation nursing protocol and systematically evaluates its impact on DVT prevention and functional recovery. Targeting a Chinese patient population with standardized care, the study compares postoperative changes in Visual Analogue Scale (VAS) scores, World Health Organization Quality of Life (WHOQOL)-BREF scores, Fugl-Meyer lower limb function scores, and other recovery indicators between groups. Additionally, the study identifies independent risk factors for DVT, offering actionable insight to optimize nursing strategies and improve patient outcome.

Materials and methods

Sample size calculation

According to Zhang et al. [13], the average incidence rate of postoperative DVT is 22.79%. Based on this incidence rate, the sample size was calculated using the formula $N = Z^2 \times [P \times (1\text{-}P)]/E^2$, where Z is the confidence level at 95% (1.96) and E is the margin of error (5%). The required sample size was approximately 270 participants. The final sample size was adjusted according to clinical conditions and patient availability to ensure statistical validity while maintaining practical feasibility.

Study design

This retrospective cohort study used hospital databases to collect clinical data on patients with lower limb traumatic fractures. All data were anonymized to protect patient privacy. The study was approved by the ethics committee of the Hanzhong Hospital of TCM, and informed consent was waived.

Participants

The study included patients treated for lower limb traumatic fractures at Hanzhong Hospital of TCM between January 2022 and December 2023. Inclusion criteria were: (1) age ≥18 years; (2) postoperative follow-up of at least one mon-

th; (3) clear diagnosis and surgical treatment; and (4) complete clinical data. Exclusion criteria were: (1) history of lower limb DVT; (2) severe preoperative comorbidities (e.g., malignancy or severe cardiopulmonary dysfunction) affecting recovery; (3) pre-existing limb paralysis; (4) coagulation disorders; and (5) pregnancy or lactation. Initially, 284 cases met the inclusion criteria. After applying the exclusion criteria, 162 cases remained eligible, consisting of 78 patients receiving conventional nursing care (control group) and 84 patients receiving early rehabilitation nursing (observation group). The study was approved by the Ethics Committee of Hanzhong Hospital of TCM.

Data collection

Baseline and postoperative recovery data were extracted from the hospital's electronic medical record system. Collected data included patient characteristics (gender, age, body mass index, ABO blood type, surgery duration, ASA score, fracture type) and rehabilitation-related indicators (catheter retention time, time to first feeding, time to first ambulation, start of exercises, recovery tolerance time, and hospital stay). Postoperative complications, such as nausea, vomiting, bloating, hematoma, urinary retention, and DVT, were recorded. The following assessment scores were used: (1) Visual Analogue Scale (VAS) [14]: Assessed preoperative and 7-day postoperative pain on a scale from 0 to 10, with higher scores indicating greater pain. (2) WHOQOL-BREF [15]: Evaluated quality of life across physical, psychological, social, and environmental domains before nursing care and one month post-intervention. Scores ranged from 4 to 20, with higher scores indicating better quality of life. (3) Fugl-Meyer Lower Limb Scores [16]: Assessed lower limb functional recovery before and one month after nursing care, with scores ranging from 0 to 34, where higher scores indicated better functional recovery.

Surgical protocol

Hip fracture: joint replacement (arthroplasty): Patients with hip fractures underwent total or partial joint replacement, depending on age, bone quality, and fracture type. Cemented or uncemented prostheses were selected based on bone density and surgeon preference. The Smith & Nephew REF 71390257 cemented total hip prosthesis was used, with Heraeus PALACOS® R+G Bone Cement containing gentamicin for fixation in cemented implants. Surgeries were performed under general or regional anesthesia (e.g., spinal or epidural). Intraoperative medications included cefazolin 2 g (Sandoz), administered intravenously 60 minutes before incision and every 8 hours for 24 hours postoperatively. To reduce bleeding, tranexamic acid 1 g (Pfizer) was administered intravenously before wound closure. Fluid management included lactated Ringer's solution or normal saline, adjusted based on intraoperative blood loss.

Femoral shaft fracture: intramedullary fixation: Femoral shaft fractures were treated with closed or open reduction followed by intramedullary nailing using Synthes REF 456.401 titanium alloy nails and locking screws from the same system for additional fixation. Fluoroscopic guidance ensured accurate alignment and stabilization throughout the procedure. Anesthesia was general or regional, as appropriate. Intraoperative medications included cefazolin 2 g (Sandoz) and tranexamic acid 1 g (Pfizer), administered as in joint replacement procedures. Fluid replacement was managed with lactated Ringer's solution or normal saline based on blood loss.

Interventions

Control group: Patients in the control group received conventional nursing care from January 2022 to December 2022. Routine care included preoperative health education and preparation to ensure normal surgical indicators, intraoperative temperature monitoring to maintain a comfortable surgical environment, and postoperative monitoring of vital signs, pain management, gradual dietary recovery, and basic lower limb activity guidance. Discharge instructions emphasized moderate lower limb movement, avoidance of weight-bearing, and timely follow-up.

Observation group: Patients in the observation group received early rehabilitation nursing from January 2023 to December 2023. The early rehabilitation protocol included multi-phase interventions during preoperative, intraoperative, and postoperative care: (1) Preoperative Care: Health education and psychological counseling to reduce anxiety, strengthen patient and family confidence in treatment, and provide personalized dietary guidance. (2) Intraoperative Care: Preference for nerve block or laryngeal mask anesthesia, control of surgery duration, and maintenance of appropriate temperatures to mini-

mize stress response and reduce the risk of hypothermia. (3) Postoperative Care: Vigilant monitoring of vital signs, pain management using VAS scores with combined pharmacologic and non-pharmacologic interventions, progressive lower limb exercises (e.g., quadriceps and ankle pump exercises) to promote joint function recovery, leg elevation, warm compresses, and infrared therapy to alleviate limb swelling. Environmental nursing included daily ward disinfection, ventilation, and clean bedding to prevent cross-infection. Dietary management focused on high nutrition and fiber intake, with instructions to stay hydrated to promote urination. Discharge education provided guidance on daily activities and key points for home rehabilitation to support gradual return to normal activities and consolidate treatment outcomes.

This early rehabilitation nursing protocol offered a systematic and personalized approach, addressing the comprehensive rehabilitation needs of patients with lower limb traumatic fractures to accelerate functional recovery, reduce complication risk, and enhance overall WHOQOL-BREF scores.

Note: All patients received one week of nursing care. See Supplementary Material for the detailed nursing protocol; the above content is a condensed version.

Outcome measurements

The primary outcome was the analysis of risk factors for DVT. Baseline data from the DVT and non-DVT groups were compared to identify independent risk factors, shedding light on key elements influencing DVT occurrence and providing a basis for postoperative care and prevention. Secondary outcomes included VAS scores, WHOQOL-BREF scores, Fugl-Meyer scores, rehabilitation indicators, and the incidencQinghua Zheng, Department of Intervention and Vascular Surgery, Hanzhong Central Hospital, No. 557, Middle Section of Laodong West Road, Hantai District, Hanzhong 723000, Shaanxi, Chinae of postoperative complications. VAS scores were used to assess pain preoperatively and at 7 days postoperatively; WHOQOL-BREF assessed quality of life before nursing care and one month post-intervention; and Fugl-Meyer scores evaluated lower limb functional recovery. Rehabilitation indicators included catheter retention time, first feeding time, first ambulation time, exercise initiation, recovery tolerance time, and hospital stay, all used to measure recovery speed. Postoperative complications focused on DVT incidence, which served to evaluate the preventive effectiveness of the nursing protocol.

Statistical analysis

Data analysis was conducted using SPSS 26.0. Categorical data were expressed as percentages and compared using the chi-square test. Continuous data were presented as mean ± standard deviation or median (interquartile range), and analyzed with an independent sample t-test or Mann-Whitney U test, depending on the results of the normality test. Multivariate logistic regression analysis was performed using R (version 4.3.3), and the forest plot in was generated using the forestplot and grid packages. The forestplot package was used to create a clear visual representation of odds ratios (ORs) and their 95% confidence intervals (CIs) for each independent risk factor of DVT, while the grid package allowed for customization of graphical elements to ensure clarity and precision. The regression results were visualized in a forest plot to display the odds ratios (ORs) and 95% confidence intervals (CIs) for each independent risk factor of DVT. All tests were two-sided, with $P<0.05$ considered significant.

Results

Comparison of baseline characteristics

Baseline characteristics between the groups showed no significant differences across multiple factors (all $P>0.05$). For instance, the proportion of patients aged ≥60 years was 52.56% in the control group and 55.95% in the observation group ($P=0.665$). Gender distribution was also similar, with males comprising 70.51% of the control group and 65.48% of the observation group ($P=0.493$). BMI categories showed comparable distributions, with 17.95% of the control group and 22.62% of the observation group classified as <21 kg/m^2 ($P=0.748$). No significant differences were observed in ABO blood type ($P=0.480$), surgery duration ($P=0.726$), ASA score ($P=0.610$), fracture type ($P=0.793$), nursing protocol ($P=0.823$), history of hypertension ($P=0.528$), or history of diabetes ($P=0.628$) (**Table 1**).

Table 1. Comparison of baseline characteristics

Factor	Control Group (n=78)	Observation Group (n=84)	Statistic	*P*-value
Age				
≥60 years	41 (52.56%)	47 (55.95%)	0.187	0.665
<60 years	37 (47.44%)	37 (44.05%)		
Gender				
Male	55 (70.51%)	55 (65.48%)	0.471	0.493
Female	23 (29.49%)	29 (34.52%)		
BMI				
<21 kg/m^2	14 (17.95%)	19 (22.62%)	0.58	0.748
21-25 kg/m^2	53 (67.95%)	53 (63.1%)		
>25 kg/m^2	11 (14.1%)	12 (14.29%)		
ABO Blood Type			0.499	0.48
O type	31 (39.74%)	38 (45.24%)		
Other types	47 (60.26%)	46 (54.76%)		
Surgery Duration				
≥120 min	43 (55.13%)	44 (52.38%)	0.123	0.726
<120 min	35 (44.87%)	40 (47.62%)		
ASA Score			0.99	0.61
I	15 (19.23%)	18 (21.43%)		
II	38 (48.72%)	45 (53.57%)		
III	25 (32.05%)	21 (25%)		
Fracture Type			0.069	0.793
Hip Fracture	48 (61.54%)	50 (59.52%)		
Femoral Shaft	30 (38.46%)	34 (40.48%)		
Surgical protocol			0.05	0.823
Joint Replacement	45 (57.69%)	47 (55.95%)		
Intramedullary Fixation	33 (42.31%)	37 (44.05%)		
Hypertension			0.397	0.528
Yes	19 (24.36%)	17 (20.24%)		
No	59 (75.64%)	67 (79.76%)		
Diabetes			0.234	0.628
Yes	10 (12.82%)	13 (15.48%)		
No	68 (87.18%)	71 (84.52%)		

Note: BMI, Body Mass Index; American Society of Anesthesiologists (ASA) Score; ABO, ABO blood group system.

Table 2. Comparison of preoperative and 7-day postoperative VAS scores

Variable	Control Group (n=78)	Observation Group (n=84)	Statistic	*P*-value
Preoperative VAS	8.00 [7.00, 9.00]	8.00 [7.00, 9.00]	0.521	0.593
7-day Postoperative VAS	3.00 [3.00, 4.00]*	2.00 [2.00, 3.00]*	6.662	<0.001

Note: * indicates P<0.05 compared to pre-nursing; VAS, Visual Analogue Scale.

Comparison of preoperative and postoperative 7-day VAS scores

Preoperative VAS scores were similar between the groups (P=0.593). However, at 7 days post-operatively, the observation group reported significantly lower VAS scores compared to the control group (**Table 2**).

Comparison of WHOQOL-BREF scores before and one month after nursing

Before nursing implementation, no significant differences were observed in WHOQOL-BREF scores across physical, psychological, social relations, or environmental domains (all P> 0.05). After one month of nursing, both groups

Table 3. Comparison of WHOQOL-BREF scores before and one month after nursing

Variable	Control Group (n=78)	Observation Group (n=84)	Statistic	*P*-value
Pre-nursing Physical	14.50 [11.00, 17.00]	14.00 [11.00, 16.00]	0.856	0.391
Post-nursing Physical	17.00 [15.00, 19.00]*	18.00 [18.00, 19.25]*	-4.048	<0.001
Pre-nursing Psychological	12.00 [10.00, 13.00]	12.13 ± 2.51	-1.185	0.233
Post-nursing Psychological	16.00 [15.00, 18.00]*	18.00 [17.00, 20.00]*	-4.388	<0.001
Pre-nursing Social Relations	5.00 [3.00, 6.00]	4.00 [3.00, 5.00]	1.612	0.101
Post-nursing Social Relations	7.00 [5.00, 8.00]*	9.00 [8.00, 10.00]*	-6.211	<0.001
Pre-nursing Environment	13.76 ± 2.40	13.24 ± 2.94	1.233	0.22
Post-nursing Environment	17.00 [15.00, 18.00]*	18.00 [17.00, 19.00]*	-4.405	<0.001

Note: * indicates P<0.05 compared to pre-nursing.

Table 4. Comparison of pre-nursing and one-month post-nursing Fugl-Meyer lower limb scores

Variable	Control Group (n=78)	Observation Group (n=84)	Statistic	*P*-value
Pre-nursing Fugl-Meyer	11.00 [10.00, 13.75]	11.00 [9.75, 14.00]	-0.504	0.612
Post-nursing Fugl-Meyer	25.23 ± 2.87*	28.00 [26.00, 31.00]*	-6.123	<0.001

Note: * indicates P<0.05 compared to pre-nursing.

Table 5. Comparison of rehabilitation indicators

Variable	Control Group (n=78)	Observation Group (n=84)	Statistic	*P*-value
Catheter Retention Time (h)	18.96 ± 5.01	15.24 ± 4.24	5.087	<0.001
First Feeding Time (h)	10.51 ± 3.81	5.00 [3.00, 8.25]	7.056	<0.001
First Ambulation Time (d)	3.00 [2.00, 4.00]	2.50 [1.00, 3.00]	2.271	0.02
Exercise Start Time (h)	24.00 [23.00, 26.00]	7.00 [6.00, 8.00]	10.981	<0.001
Rehabilitation Tolerance Time (min)	5.00 [4.00, 7.00]	10.68 ± 4.91	-7.257	<0.001
Hospital Stay (d)	7.00 [6.00, 8.00]	5.00 [3.00, 6.00]	6.226	<0.001

showed significant improvements (all P<0.05). However, the observation group demonstrated significantly higher scores across all domains compared to the control group (all P<0.001) (**Table 3**).

Comparison of Fugl-Meyer lower limb scores before and one month after nursing

Pre-nursing Fugl-Meyer lower limb scores were comparable between the two groups (P>0.05). After one month of nursing, both groups exhibited significant improvements (P<0.05), with the observation group showing significantly higher scores (P<0.001) (**Table 4**).

Comparison of rehabilitation indicators

The observation group demonstrated faster progress across all rehabilitation indicators compared to the control group. Specifically, the observation group had significantly shorter catheter retention time (P<0.001), time to first feeding (P<0.001), first ambulation time (P= 0.02), initiation of exercises (P<0.001), rehabilitation tolerance time (P<0.001), and hospital stay (P<0.001) (**Table 5**).

Comparison of postoperative complications

Postoperative complications, including nausea and vomiting (P=1.000), abdominal distension (P=0.948), hematoma (P=0.389), urinary retention (P=0.638), and secondary infection (P=0.948), showed no significant differences between the groups. However, the incidence of DVT was significantly higher in the control group compared to the observation group (P=0.002) (**Figure 1**).

DVT risk factor analysis

Risk factors for DVT occurring within 7 days post-surgery were analyzed, including preoperative VAS scores, pre-nursing Fugl-Meyer scores, catheter retention time, time to first feed-

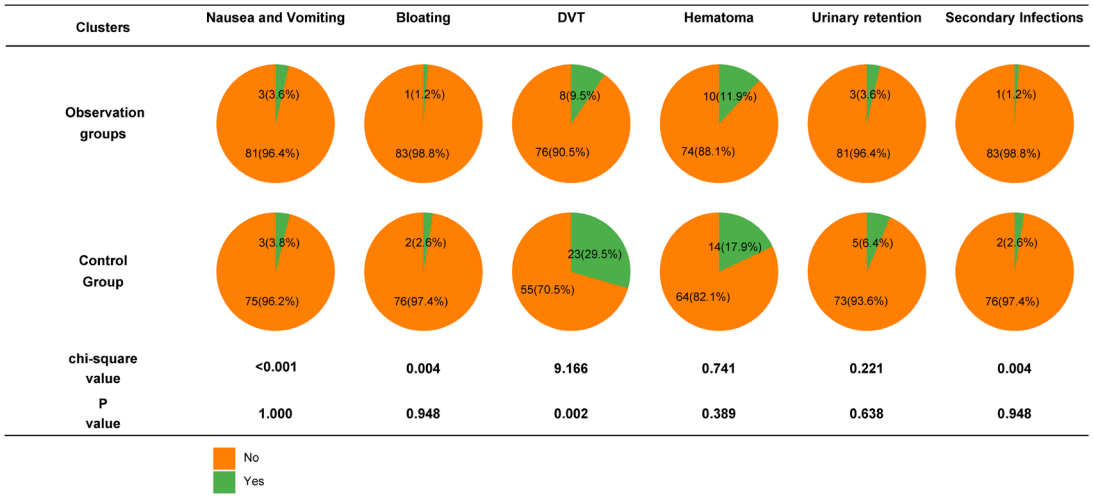

Figure 1. Comparison of postoperative complications.

ing, first ambulation time, initiation of exercises, rehabilitation tolerance time, nursing protocol, age, gender, BMI, ABO blood type, surgery time, ASA score, fracture type, treatment protocol, hypertension history, and diabetes history. Postoperative digestive function and social support were excluded as indirect factors.

Significant differences were found in nursing protocol, age, BMI, ABO blood type, and catheter retention time between the DVT (n=31) and non-DVT (n=129) groups. The proportion of control group patients was significantly higher in the DVT group (74.19%) compared to the non-DVT group (41.98%, P=0.001). Patients aged ≥60 years were more common in the DVT group (70.97%) than in the non-DVT group (45.8%, P=0.012). Patients with a BMI <21 kg/m^2 were less prevalent in the DVT group (P=0.029), while non-O blood types were more common in the DVT group (P=0.012). Catheter retention time was significantly longer in the DVT group (P=0.027). No significant differences were observed in gender, surgery time, ASA score, fracture type, hypertension history, diabetes history, preoperative VAS score, or pre-nursing Fugl-Meyer scores (all P>0.05) (see **Table 6**).

Multivariate logistic regression analysis for DVT

Multivariate logistic regression analysis included variables with significant baseline differences between the DVT and non-DVT groups (see **Table 7**). The analysis revealed significant associations between nursing protocol, age, BMI, and catheter retention time with DVT occurrence. Specifically: Patients in the observation group had a significantly lower risk of DVT compared to the control group (OR=3.086, P=0.024). Patients aged ≥60 years exhibited an increased risk of DVT (OR=2.589, P=0.043). A BMI of 21-25 kg/m^2 was associated with a lower DVT risk (OR=2.444, P=0.037). A catheter retention time of ≥19.5 hours increased the risk of DVT, though not significantly (OR=2.401, P=0.061).

ABO blood type did not significantly affect DVT risk (P=0.104). Sankey diagrams visually illustrated these relationships (see **Figure 2**), and forest plots summarized the odds ratios and confidence intervals for DVT risk factors (see **Figure 3**).

Discussion

This study examined the effectiveness of early rehabilitation nursing in preventing postoperative DVT and promoting lower limb functional recovery in patients with traumatic lower limb fractures, focusing on identifying DVT risk factors. The results demonstrate that early rehabilitation nursing significantly alleviates pain, promotes functional recovery, improves quality of life, shortens rehabilitation time, and effectively reduces DVT incidence. Additionally, multivariate analysis identified nursing protocol,

Table 6. Comparison of baseline characteristics between DVT and Non-DVT groups

Variable	DVT Group (n=31)	Non-DVT Group (n=129)	Statistic	*P*-value
Nursing plan				
Control group	23 (74.19%)	55 (41.98%)	10.417	0.001
Observation group	8 (25.81%)	76 (58.02%)		
Age				
≥60 years	22 (70.97%)	60 (45.8%)	6.352	0.012
<60 years	9 (29.03%)	71 (54.2%)		
Gender				
Male	23 (74.19%)	87 (66.41%)	0.696	0.404
Female	8 (25.81%)	44 (33.59%)		
BMI				
<21 kg/m^2	1 (3.23%)	32 (24.43%)	7.092	0.029
21-25 kg/m^2	24 (77.42%)	82 (62.6%)		
>25 kg/m^2	6 (19.35%)	17 (12.98%)		
ABO Blood Type				
O type	7 (22.58%)	62 (47.33%)	6.279	0.012
Other types	24 (77.42%)	69 (52.67%)		
Surgery Duration				
≥120 min	19 (61.29%)	68 (51.91%)	0.887	0.346
<120 min	12 (38.71%)	63 (48.09%)		
ASA Score				
I	4 (12.9%)	29 (22.14%)	1.404	0.496
II	18 (58.06%)	65 (49.62%)		
III	9 (29.03%)	37 (28.24%)		
Fracture Type				
Hip Fracture	20 (64.52%)	78 (59.54%)	0.260	0.610
Femoral Shaft	11 (35.48%)	53 (40.46%)		
Surgical protocol				
Joint Replacement	18 (58.06%)	74 (56.49%)	0.025	0.873
Intramedullary Fixation	13 (41.94%)	57 (43.51%)		
Hypertension				
Yes	5 (16.13%)	31 (23.66%)	0.823	0.364
No	26 (83.87%)	100 (76.34%)		
Diabetes				
Yes	3 (9.68%)	20 (15.27%)	0.643	0.423
No	28 (90.32%)	111 (84.73%)		
VAS before care	8.00 [7.00, 9.00]	8.00 [7.00, 9.00]	0.344	0.731
Fugl-Meyer before care	12.00 [9.00, 14.00]	11.00 [10.00, 13.50]	0.172	0.864
Catheter Retention Time (h)	18.81 ± 5.15	16.61 ± 4.86	-2.237	0.027
First Feeding Time (h)	10.00 [5.50, 13.00]	7.00 [4.50, 10.50]	1.915	0.056
First Ambulation Time (d)	3.00 [2.00, 3.50]	3.00 [1.00, 3.00]	0.648	0.517
Rehabilitation Tolerance Time (min)	6.00 [4.50, 7.50]	7.00 [5.00, 11.00]	1.607	0.108

Note: BMI, Body Mass Index; American Society of Anesthesiologists (ASA) Score; ABO, ABO blood group system; VAS, Visual Analogue Scale.

age, BMI, and catheter retention time as independent risk factors for DVT, offering novel intervention strategies for clinical care.

DVT is a common postoperative complication in patients with traumatic lower limb fractures. Our study showed that early rehabilitation

Table 7. Variable assignment for multivariate analysis

Variable	Type	Assignment Details
Nursing Protocol	X	Control Group = 1, Observation Group = 0
Age	X	≥60 years = 1, <60 years = 0
BMI	X	<21 kg/m^2 = 0, 21-25 kg/m^2 = 1, >25 kg/m^2 = 2
ABO Blood Type	X	O type = 1, Others = 0
Catheter Retention Time	X	<19.5 h = 0, ≥19.5 h = 1
DVT	Y	Yes = 1, No = 0

Note: BMI, Body Mass Index; American Society of Anesthesiologists (ASA) Score; ABO, ABO blood group system; VAS, Visual Analogue Scale.

nursing significantly reduces DVT incidence by shortening bed rest, progressively increasing lower limb activity, and promoting early ambulation post-surgery [17]. The observation group had a notably lower DVT incidence than the control group, reinforcing the role of early rehabilitation nursing in DVT prevention. Unlike traditional care models, early rehabilitation nursing emphasizes early, guided light activities such as ankle pumps and quadriceps contractions, which enhance venous blood flow, reduce venous stasis, and decrease thrombosis risk. Previous studies also highlight early mobilization as a critical strategy for DVT prevention. For instance, Meng et al. [18] reported that delayed mobilization increased DVT risk in patients with ankle fractures, while Aprisunadi et al. [19] found that early mobilization after hip and lower limb surgeries significantly reduced hospital stays, lowered complication rates, and improved both walking ability and overall quality of life. These findings align with ours, underscoring the effectiveness of early rehabilitation nursing in reducing DVT risk.

Restoring lower limb function is essential for postoperative recovery in patients with traumatic lower limb fractures. Our study found that the observation group achieved significantly higher Fugl-Meyer scores one month after surgery, emphasizing the positive effect of early rehabilitation nursing on functional recovery. Personalized exercise plans, including both active and passive lower limb exercises, ankle pumps, and quadriceps contractions, effectively enhance muscle strength and joint flexibility, preventing complications like muscle atrophy and joint stiffness due to prolonged bed rest [20]. These findings are supported by previous studies. For example, Yu et al. [21] reported that systematic early rehabilitation nursing significantly improved limb function and quality of life in elderly patients, while alleviating psychological stress related to functional loss. Similarly, Yang et al. [22] demonstrated that rehabilitation nursing based on Orem's self-care theory resulted in substantial improvement in the Barthel Index and Fugl-Meyer scores. Wu et al. [23] also confirmed that early intervention in acute stroke patients not only improved treatment success and nursing satisfaction but also enhanced limb function and activities of daily living. These studies support our findings, reinforcing the conclusion that early rehabilitation nursing, guided by scientific principles, plays a crucial role in facilitating comprehensive lower limb functional recovery.

Another key outcome of early rehabilitation nursing is its significant positive impact on quality of life. In this study, the observation group showed notably higher WHOQOL-BREF scores across physical, psychological, social, and environmental domains one month after surgery. Early rehabilitation nursing not only supports physical recovery but also addresses patients' anxiety and boosts their confidence through psychological counseling and health education. Previous literature supports the role of rehabilitation nursing in improving psychological well-being and overall quality of life [24]. For instance, Liu et al. [25] found that continuous care significantly enhanced quality of life and functional recovery in patients after hip fractures. Similarly, Ruan et al. [26] reported significant improvements in SF-36 quality of life scores and nursing satisfaction following rehabilitation care interventions. These findings are consistent with our study, reinforcing the conclusion that systematic and tailored nursing interventions can profoundly enhance quality of life and patient satisfaction.

Furthermore, our study confirms that early rehabilitation nursing significantly reduced DVT

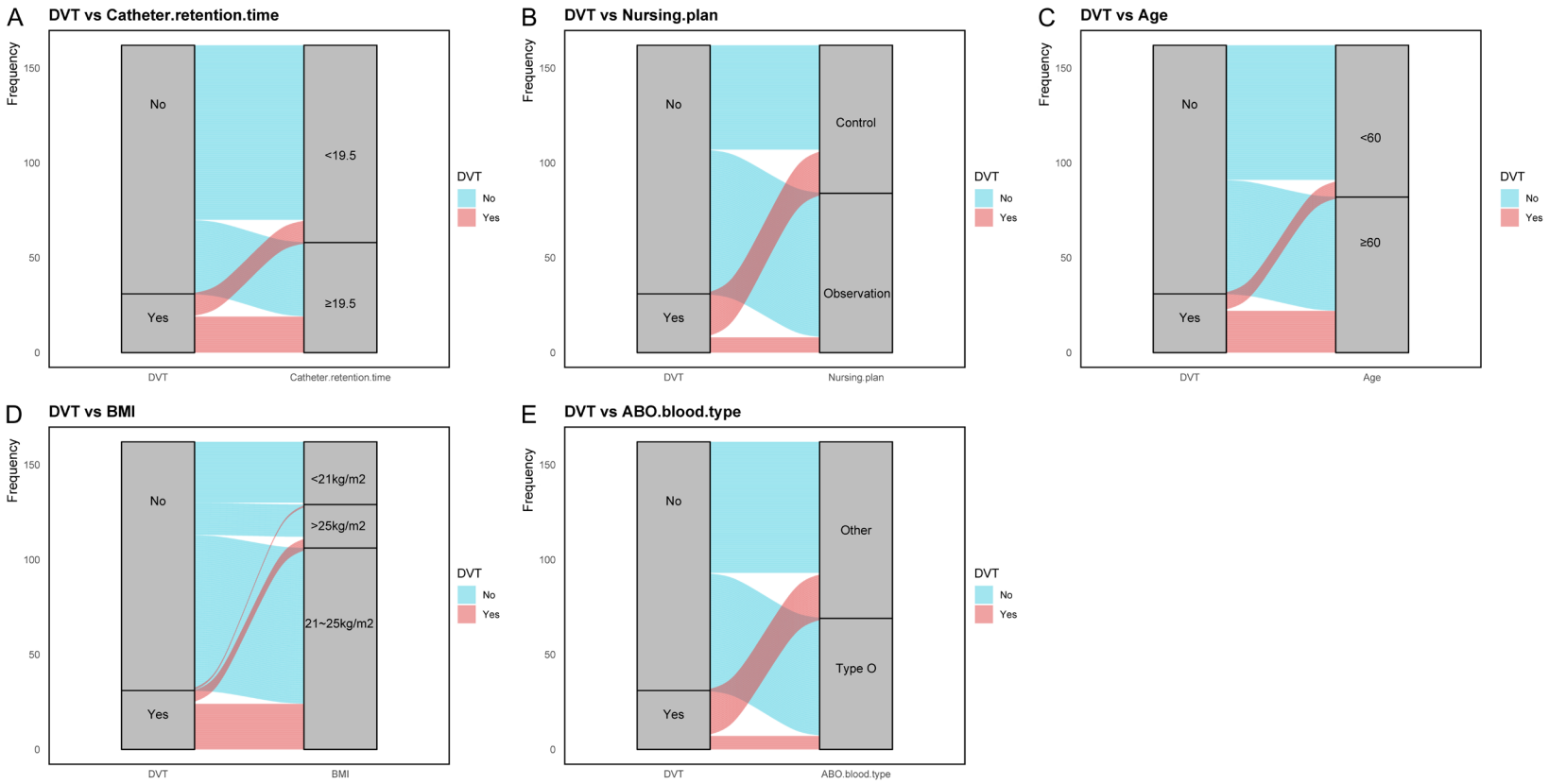

Figure 2. Sankey Diagram of DVT Risk Factors. A: Catheter Retention Time and DVT Association. B: Nursing Protocol and DVT Association. C: Age and DVT Association. D: BMI and DVT Association. E: ABO Blood Type and DVT Association. Note: Body Mass Index (BMI); American Society of Anesthesiologists (ASA) Score; ABO blood group system (ABO); Visual Analogue Scale (VAS).

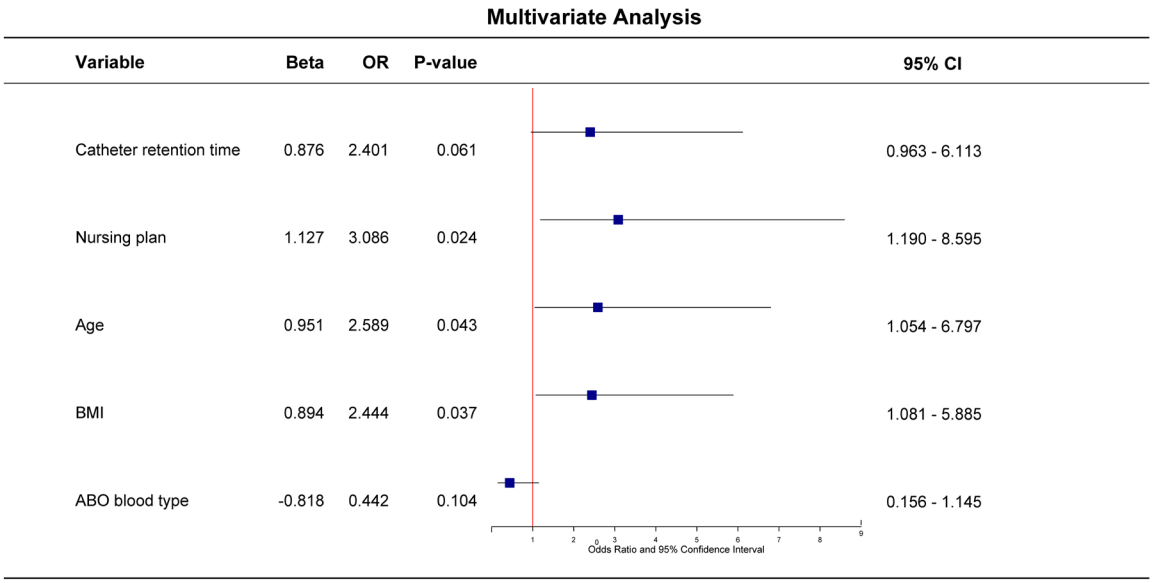

Figure 3. Results of multivariate logistic regression analysis for DVT Occurrence. Note: Body Mass Index (BMI); American Society of Anesthesiologists (ASA) Score; ABO blood group system (ABO); Visual Analogue Scale (VAS).

incidence compared to conventional nursing care. Identified risk factors, including age ≥60 years, abnormal BMI (both high and low), and prolonged catheter retention, provide actionable insights for clinical practice. Consistent with our findings, Chen et al. [27] identified age, elevated D-dimer levels, and fibrinogen as key risk factors for DVT in elderly patients with femoral neck fracture, highlighting the heightened risk among older patients and those with higher BMI due to reduced vascular elasticity, prolonged immobility, and coagulation changes. Prolonged catheter retention was also identified as an independent risk factor in our study. Zhang et al. [28] reported that extended bed rest and preoperative waiting times significantly increased DVT incidence in fracture patients, while Meng et al. [18] similarly linked prolonged waiting times with elevated DVT risk in ankle fracture patients. These studies align with our findings, demonstrating that prolonged immobility and catheter retention impede venous blood flow in the lower limbs, increasing the likelihood of DVT.

Our study also highlights the association between BMI and DVT risk. Patients with low BMI may lack adequate muscle support for effective venous circulation, while those with higher BMI may experience obstructed venous return due to weight-induced pressure on blood vessels. These findings are supported by Ruan et al. [25], who noted that rehabilitation nursing can improve hemorheological status, reducing DVT risk in patients with lower limb fractures. This evidence underscores the importance of integrating weight management strategies, including exercise and dietary guidance, into nursing interventions to enhance venous circulation and mitigate DVT risk.

Our findings underscore the significant role of early rehabilitation nursing in reducing the risk of DVT in postoperative care for patients with lower limb traumatic fractures. For high-risk patients - particularly those who are elderly, have abnormal BMI, or require prolonged bed rest - early rehabilitation intervention should be prioritized to mitigate DVT risk. Consistent with related literature [18, 20], implementing systematic and individualized care strategies can optimize postoperative recovery, minimize complications, shorten hospital stays, and ultimately achieve a long-term recovery.

Despite the promising outcomes, this study has certain limitations. First, as a single-center retrospective study, the potential for selection bias and the relatively small sample size may limit the generalizability of the results. Second, the short follow-up period precluded a thorough evaluation of the long-term effects of early rehabilitation nursing on patient outcome. Additionally, variations in patient adherence to nursing interventions may have influenced the eff-

ectiveness of the protocols. To address these limitations, future research should focus on multicenter, prospective studies with larger sample sizes and extended follow-up periods to validate these findings for the long-term.

In conclusion, this study demonstrates that early rehabilitation nursing is significantly effective in preventing DVT and promoting lower limb functional recovery in patients with lower limb traumatic fractures, effectively reducing rehabilitation time and enhancing quality of life. Nursing protocol, age, BMI, and catheter retention time were independent risk factors for DVT, warranting attention in clinical care. Through systematic, individualized interventions, early rehabilitation nursing helps improve postoperative prognosis and should be further promoted and optimized to provide comprehensive support for the postoperative recovery of patients with lower limb traumatic fractures.

Disclosure of conflict of interest

None.

Address correspondence to: Qinghua Zheng, Department of Intervention and Vascular Surgery, Hanzhong Central Hospital, No. 557, Middle Section of Laodong West Road, Hantai District, Hanzhong 723000, Shaanxi, China. E-mail: lanpi2002@163.com

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Supplementary Material

Control group nursing plan

Patients in the control group receive standard nursing care focused on basic care and postoperative recovery support, including preoperative, intraoperative, and postoperative basic needs:

Preoperative care

Health education: Introduce patients to the basics of lower limb fractures and surgery, including the procedure, precautions, and basic postoperative recovery requirements to boost confidence in the surgery.

Preoperative preparation: Assist patients with preoperative examinations to ensure surgical indicators are normal. Enforce a 6-hour fasting period and 2-hour water restriction before surgery for optimal preparation.

Intraoperative care

Temperature and comfort care: Monitor body temperature during surgery and maintain an appropriate operating room temperature to keep patients comfortable and prevent hypothermia.

Postoperative care

Vital signs monitoring: Regularly monitor vital signs post-surgery, recording them every 2 hours, focusing on temperature, pulse, blood pressure, and respiratory rates to detect any abnormal changes.

Pain management: Assess postoperative pain using the VAS scale, administer pain relief medication based on the assessment, guide deep breathing for relaxation, and help divert attention.

Dietary guidance: Once awake, guide patients to gradually resume eating, starting with small amounts of fluids within 4 hours post-surgery, progressing to a regular diet as gastrointestinal function returns.

Limb function guidance: Assist patients in basic lower limb exercises under medical supervision, like ankle pumps, to promote blood circulation and prevent thrombosis; advise suitable resting positions.

Environmental management: Maintain a clean and ventilated ward by regularly cleaning the ward and bedding to prevent cross-infection, ensuring a good hospital environment.

Discharge guidance

Rehabilitation and lifestyle guidance: Provide patients and their families with a brief guide on daily precautions, encourage moderate lower limb activity to support recovery, advise against heavy or strenuous activities, remind them of follow-up visits, and adhere to postoperative care instructions.

Observation group early rehabilitation nursing Intervention plan for lower limb traumatic fractures

Preoperative care

Health education: Conduct health education upon admission for patients and families, covering fracture causes, surgical purpose, procedure, significance of rehabilitation, and precautions. Use educational booklets and videos to enhance understanding and compliance.

Psychological support: Assess psychological stress and emotional state, paying attention to anxiety and worries. Tailor psychological interventions according to cultural background and cognitive levels, sharing recovery success stories to build confidence.

Dietary guidance: Recommend high-calorie, easily digestible foods preoperatively, avoiding stimulants. If gastrointestinal function is normal, restrict solid foods 6 hours preoperatively and water 2 hours prior, with small carbohydrate drinks allowed 2-3 hours pre-surgery.

Intraoperative care

Anesthesia and surgery optimization: Opt for anesthesia with minimal impact on lower limb trauma patients, such as nerve block or laryngeal mask anesthesia, limiting general anesthesia to minimize postoperative stress.

Temperature control: Adjust the operating room temperature, especially for elderly patients, to prevent hypothermia-related complications like fat embolism.

Postoperative care

Vital signs monitoring: Strictly monitor vital signs post-surgery, recording hourly to observe patient status and ensure stability, reducing the risk of complications.

Pain management: Complete the first pain assessment within 8 hours post-admission using the VAS scale and implement personalized pain management. Reassess mild pain daily and moderate or severe pain every 8 hours. Follow prescribed medication and offer non-drug interventions like music therapy and deep breathing.

Limb function exercises: Early postoperative guidance on lower limb exercises based on fracture location, including quadriceps contraction and ankle pumps. Gradually add joint flexion to prevent tendon adhesions and promote recovery.

Limb elevation: Elevate the affected limb 15-20 cm to promote blood flow and reduce postoperative swelling. Use warm magnesium sulfate compresses and infrared light for 30 minutes twice daily for a week.

Environmental care: Maintain a clean ward, disinfect morning and evening, clean the restroom regularly, and ensure proper ventilation, opening windows at least three times daily to prevent cross-infection. Ensure bed, pillow, and mattress cleanliness to ease patient comfort.

Daily life and dietary management

Dietary guidance: Gradually restore diet once awake, starting with fluids 4 hours post-surgery and resuming a regular diet after two days. Emphasize intake of vitamins, proteins, and fiber, encourage fresh vegetables and fruits to ensure regular bowel movements, and avoid spicy or irritating foods.

Pressure ulcer prevention: Since patients may avoid movement due to pain, teach families correct bed rest positions, assist with skin care and moist compresses to prevent pressure ulcers.

Urinary promotion: Encourage fluid intake to facilitate urination, helping prevent postoperative urinary retention and other complications.

Discharge guidance

Discharge education: Educate patients and families on daily activity precautions, personal hygiene, and regular follow-ups. Advise moderate activity increase and a positive mindset to support sustained recovery.

Home rehabilitation guidance: Provide guidance on home rehabilitation exercises, including lower limb strength and joint mobility training, with advice on posture and frequency to avoid reinjury.