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Original Article

Effects of rehabilitation nursing care on deep vein thrombosis of the lower limbs following spinal fractures

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Abstract: Objective: To explore the preventive effect of rehabilitation nursing care for deep vein thrombosis (DVT) of the lower limbs following spinal fractures, and to analyze its influence on the hemorheology of patients. Methods: A total of 99 patients with spinal fractures were allocated into a study group (n=50) and control group (n=49), and they were treated with internal fixation plus vertebroplasty. Afterwards, patients in the control group were given routine care and postoperative rehabilitation, and those in the study group received rehabilitation nursing care on the day after surgery, including posture guidance, massage of both lower limbs, and functional training. The functional training was consecutively performed until free movement of the legs was possible. All patients were reexamined after three months. The incidence of low-limb DVT, pain, and swelling, as well as the degree of swelling, hemorheology, quality of life, and patient satisfaction were compared between the two groups. Results: The study group had less frequent low-limb DVT, pain and swelling than the control group (all $P<0.05$). In the study group, the degree of swelling was significantly reduced, with earlier return to normal activity and shorter hospital stay (all $P<0.05$). After intervention, plasma viscosity, whole blood low/high shear viscosity and erythrocyte aggregation (EA) decreased in both groups, especially in the study group (all $P<0.05$). Although GQOL-74 scores increased in both groups, there was a more significant increase that occurred in study group (all $P<0.001$). Patients in the study group were more satisfied with nursing services than those in the control group ($P<0.05$). Conclusion: Rehabilitation nursing care contributes to the improvement of hypercoagulable states and the prevention of lower-limb DVT for surgically treated patients with spinal fractures, and it is effective in relieving pain and swelling of the lower limbs, thereby enhancing quality of life and patient satisfaction.

Keywords: Rehabilitation nursing care, spinal fracture, deep venous thrombosis of the lower limbs, hemorheology

Introduction

Spinal fractures are associated with severe pain and a lengthy process of rehabilitation, in which patients have to rest in bed for a long time, thereby reducing the activities of the lower limbs and slowing down venous blood flow, ultimately resulting in an increased risk of deep venous thrombosis (DVT) [1]. DVT occurs frequently in the lower limbs, and rarely in the upper limbs [2]. It blocks distal blood reflux and causes pain and limb swelling, and even leads to life-threatening pulmonary embolism in patients with delayed treatment [3]. Therefore, taking effective intervention measures to prevent DVT of the lower limbs is of great practical significance to improve patients' quality of life and reduce the risk of pulmonary embolism following spinal fractures. Taking patients as the core, rehabilitation nursing care takes targeted nursing measures to provide individualized services for patients [4]. For those with spinal fractures, massage is helpful to eliminate venous congestion and promote blood circulation with reasonable rehabilitation measures, thus effectively preventing lower-limb DVT [5]. The effect of rehabilitation nursing care on DVT following spinal fractures has been widely studied [6], but the reported DVT incidence varies significantly, and the influence of this nursing mode on hemorheology remains unknown [7, 8]. Therefore, the present study aims to explore the preventive effect of rehabilitation nursing care for DVT of the lower limbs following spinal fractures, and to analyze its influence on the hemorheology of patients.

Materials and methods

General data

A total of 99 patients with spinal fractures treated in Linyi Central Hospital from February, 2019 to January, 2020 were randomly designated to a study group (n=50) and a control group (n=49). The general data of patients were shown in **Table 1**. The present study was approved by the Medical Ethics Committee of Linyi Central Hospital. Inclusion criteria: patients aged 25-65 years; spinal fractures caused by falls, traffic accident, impacts of heavy objects; patients with spinal fractures only and no other complicated injuries; patients receiving internal fixation plus vertebroplasty after admission; patients taking no anticoagulants 2 months prior to this experiment; patients who signed the informed consent. Exclusion criteria: patients complicated with injuries of the spinal cord, nerves or viscera; patients with a history of thrombosis; patients with hematological diseases or coagulation disorders; patients who participated in other research projects at the same time; patients with malignant tumors.

Methods

All patients were treated with internal fixation plus vertebroplasty, followed by low molecular weight heparin (LMWH), to prevent lower-limb DVT after surgery [9]. The control group was given routine care and rehabilitation measures: postoperative reactions and blood loss, daily urine output and blood pressure were monitored, and guidance on diet and medication was performed. On the second day after surgery, the patients were instructed to perform straight-leg raising exercises (10 raises/time, 2-3 times/d, with increased frequency and duration in patients without pain and discomfort). The study group received rehabilitation nursing care on the day after surgery [10]: (1) Postural guidance: after surgery, the patients were instructed to lie in a supine position and raise both lower limbs to accelerate blood circulation. (2) Lower limb massage: family members massaged the lower limbs on the day after surgery, 30 min/time, once every 2 to 3 hrs. In addition, a plantar arteriovenous pump (Taibao Medical Technology Co., Ltd., Guangdong, China, AV6000) was adopted, with pulse pressure of 12.0-16.0 kPa, pulse duration of 3 s, massage duration of 30 min/time, twice/d, to prevent thrombosis of lower limbs. (3) Functional training: after recovery from anesthesia, patients were guided to start stretching training of the quadriceps femoris and lower limbs once every 2-3 hrs. On the second day after surgery, straight-leg raising exercises were performed (20-30 raises/time, preferably by 30°-50°). Three days after surgery, the angle was increased to 70°-80°, gradually, not to exhaust the patients. The functional training was carried out until the patients could get out of bed and move independently. Thrombolytic therapies, such as LMWH, urokinase or intracavitary thrombus clearance, were given to patients with lower-limb DVT in time. The above exercises were continued until thrombosis was relieved. Patients were reexamined after 3 months. At the end, relevant questionnaires were filled out on the spot and returned immediately.

Outcome measures

Main outcome measures: (1) Incidence of DVT, pain and swelling during hospitalization: when sudden pain and swelling of the lower limbs occurred, patients were examined by color Doppler ultrasound. Positive Homan's signs indicated the presence of lower-limb DVT: sudden pain and swelling of the lower limbs; significant tenderness in the inner thigh; filling of superficial veins and tenderness along deep veins; solid isoechoic mass, thickened venous wall and slowed blood flow in Color Doppler ultrasound [11].

(2) Swelling of the lower limbs: The difference in the circumference of the lower limbs 2 weeks after surgery and before surgery was considered as the degree of swelling.

(3) Before intervention and after one month of intervention, 5mL of venous blood was taken from patients, and the hemorheological markers of plasma viscosity, whole blood low/high shear viscosity and erythrocyte aggregation (EA) were determined by an automatic hemorheology analyzer (Hengtuo Analytical Instrument Co., Ltd., Zibo, China, HT100). For patients with lower-limb DVT, the testing was carried out 7 days after the cure of thrombosis.

Secondary outcome measures: (1) The time to return to normal activity and the length of hospital stay were compared between the two groups. The time to return to normal activity

Table 1. Comparison of baseline data between the two groups (n, $\bar{x} \pm sd$)

Index	Study group (n=50)	Control group (n=49)	χ^2/t	P
Gender (n)			0.489	0.484
Male	28	24		
Female	22	25		
Age (year)	48.5±5.4	49.2±6.1	0.604	0.547
BMI (kg/m^2)	23.20±2.22	23.04±2.05	0.373	0.710
Fracture site (n)			0.847	0.655
Cervical fracture	14	11		
Thoracic spine fracture	16	14		
Lumbar fractures	20	24		
Spinal fracture segment (n)			0.802	0.681
Neck 6	14	11		
Chest 11	9	7		
Chest 12	7	7		
Waist 1	20	24		
Fracture type (n)			0.810	0.368
Stable fracture	29	24		
Unstable fracture	21	25		
Time from fracture to operation (h)	13.22±3.29	12.86±2.95	0.573	0.568
Intraoperative blood loss (mL)	104.44±10.09	102.95±9.74	0.748	0.457
Operation time (min)	148.49±15.40	150.08±18.44	0.465	0.643
Cause of injury (n)			0.886	0.642
Falling from height	12	9		
Car accident	26	30		
Heavy objects	12	10		
Complications (n)			0.795	0.672
Diabetes	4	5		
Hypertension	18	14		
Hyperlipidemia	9	11		
Arrhythmia	2	1		
Smoking history (n)			0.123	0.726
Yes	18	16		
No	32	33		
Drinking history (n)			0.247	0.619
Yes	22	24		
No	28	25		

Note: BMI: Body mass index.

refers to the first time when the patient can get out of bed independently.

(2) Generic quality of life inventory-74 (GQOL-74) was used to evaluate patients' quality of life before and after the intervention (taking the time of discharge as the time point of "after intervention"), including social function, emotions, physical and psychological functioning, with 100 points for each item [12]. A higher score indicated better quality of life.

(3) At discharge, patients were asked to fill out satisfaction questionnaires to evaluate their satisfaction with nursing services [13]. Satisfaction rate = (satisfied + moderately satisfied cases)/total cases * 100%.

Statistical analysis

Data processing was performed with SPSS 20.0. The categorical data were expressed as number/percentage (n/%) and analyzed by χ^2

Table 2. Comparison of the incidence of deep vein thrombosis, pain and swelling of the lower extremities between the two groups (n (%))

Group	DVT	Pain	Swelling
Study group (n=50)	1 (2.00)	4 (8.00)	4 (8.00)
Control group (n=49)	6 (12.24)	12(24.49)	12 (24.49)
χ^2	3.953	4.966	4.966
P	0.047	0.026	0.026

Note: DVT: deep vein thrombosis.

Table 3. Comparison of relevant clinical indicators between the two groups of patients ($\bar{x}$ ± sd)

Group	Swelling of lower limbs (cm)	Get out of bed time (d)	Hospital stay (d)
Study group (n=50)	0.55±0.14	7.88±1.40	12.20±3.74
Control group (n=49)	0.63±0.17	8.53±1.30	15.48±3.29
t	2.553	2.394	4.636
P	0.012	0.019	<0.001

test. The continuous data were expressed by mean ± standard deviation ($\bar{x}$ ± sd). Paired t test was used for intra-group comparison, and independent t test was used for inter-group comparison. A value of $P<0.05$ was considered to be statistically significant.

Results

Baseline data

There was no significant difference in general baseline data between the two groups (P>0.05), indicating a comparability. See **Table 1**.

Incidence of DVT, pain and swelling of the lower limbs

The study group had less frequent low-limb DVT, pain and swelling than the control group (all P<0.05). See **Table 2**.

Relevant clinical indicators

Compared with control group, the degree of swelling of the lower limbs in study group was significantly reduced, with earlier return to normal activity and shorter hospital stay (all P<0.05). See **Table 3**.

Hemorheological alteration

After intervention, the plasma viscosity, whole blood low shear/high shear viscosity and EA decreased in both groups, especially in the study group (all P<0.05). See **Table 4**.

Quality of life

Before intervention, the GQOL-74 scores in study group and control group were (276.60±22.29) and (278.20±25.48), respectively. After intervention, the scores in the two groups were (318.27±22.07) and (297.06±20.04). Therefore, the GQOL-74 scores increased in both groups after intervention, and the increase was more significant in the study group (all P<0.01). See **Figure 1**.

Patient satisfaction

Patients in study group were more satisfied with our nursing services than those in control group (P<0.05). See **Table 5**.

Discussion

Vein wall injury, slow blood flow and hypercoagulable blood are the three major factors of DVT [14]. However, due to long-term bed rest and influence of surgical trauma and stress, blood flow is usually slowed down and the blood is in a hypercoagulable state, as such DVT of the lower limbs easily occurs after surgery [15]. It is a common and serious complication following spinal fracture and resulting surgery, with an estimated incidence of 5.0%-70% [7, 8]. Sharpe et al. report that the incidence of lower-limb DVT in patients with spinal fractures is 20.3%, but can be reduced to 2.2% with reasonable anticoagulation treatment and high-quality nursing measures [16]. In the present study, the incidence in the control group was 12.24%, lower than 20.3%, and that in the study group was 2.2%, close to the reported rate of 2.2%. This suggests that nursing mode has a significant influence on the occurrence of lower-limb DVT; so taking reasonable and effective nursing measures after surgery is of great importance.

Firstly, our findings demonstrated that the study group had less frequent low-limb DVT, pain and swelling, as well as earlier return to normal activity and shorter hospital stay, indi-

Table 4. Comparison of hemorheology between the two groups of patients before and after intervention ($\bar{x} \pm sd$)

Group	Plasma viscosity (mpa·s)	Whole blood low shear viscosity (mpa·s)	Whole blood high shear viscosity (mpa·s)	EA
Study group (n=50)				
Before intervention	1.65±0.34	9.35±1.01	5.02±0.75	2.54±0.40
After intervention	1.40±0.18$^{***,\#}$	8.73±0.79$^{***,\#}$	4.30±0.73$^{***,\#}$	2.11±0.37$^{***,\#}$
Control group (n=49)				
Before intervention	1.62±0.30	9.37±0.77	4.98±0.71	2.49±0.39
After intervention	1.50±0.29*	9.08±0.58*	4.60±0.68**	2.28±0.30**

Note: Compared with before intervention, *P<0.05, **P<0.01, ***P<0.001; compared with control group, $^{\#}$P<0.05. EA: erythrocyte aggregation.

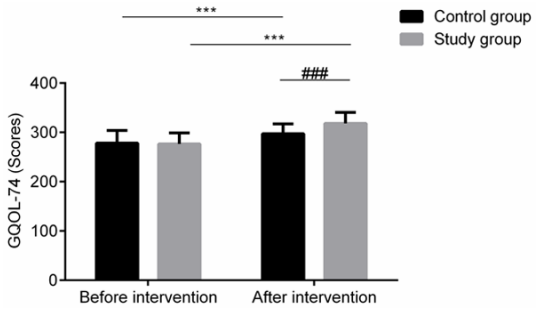

Figure 1. Comparison of GQOL-74 scores before and after intervention between the two groups. Compared with before intervention, ***P<0.001; compared with control group, $^{\#\#\#}$P<0.001. GQOL-74: Generic quality of life inventory-74.

cating that rehabilitation nursing care is effective in preventing low-limb DVT and relieving clinical symptoms. Li et al. also believe that comprehensive rehabilitation nursing is markedly helpful to prevent this disease in patients treated with fracture surgery [6]. Rehabilitation process attaches importance to the passive and active movement of the lower limbs. First of all, posture guidance alleviates postoperative stress reaction and increases vein patency [17]. Secondly, massage and functional training contribute to the improvement of blood circulation, blood flow and hemorheology of the lower limbs, thereby reducing the risk of DVT [18]. Moreover, massage of the lower limbs can comfort patients and relieve symptoms such as pain and swelling [19].

Afterwards, hemorheological changes shown in this study revealed that the plasma viscosity, whole blood low/high shear viscosity and EA decreased in both groups after intervention, especially in the study group. Therefore, rehabilitation nursing care significantly improves postoperative hemorheology and reduces the hypercoagulability in patients with spinal fractures, ultimately prevents DVT of the lower limbs. There has been evidence that early massage and functional exercise of both lower limbs after surgery reduce hypercoagulability and lower the risk of DVT [20, 21]. The mechanism underlying this regulation lies in the accelerated blood circulation and increased blood flow of the lower limbs [18].

Next, we evaluated the quality of life of patients in both groups before and after the intervention by GQOL-74. It turned out that the GQOL-74 scores increased in both groups after intervention, and a more significant increase occurred in the study group. This suggests that rehabilitation nursing care better enhances postoperative quality of life of patients with spinal fractures than routine care, which is similar to the findings of Alexiou et al. revealing that effective nursing intervention after fracture surgery can not only boost patient rehabilitation, but also improve their quality of life [22]. In the end, we found that the satisfaction of patients in the study group was higher than that in the control group, indicating that patients are more satisfied with the services in rehabilitation nursing care. This is a single-centered study with a small sample size and no follow-ups were performed, so the prevention effect of rehabilitation nursing care against DVT after discharge remains undefined. We will address these limitations to supplement our conclusions.

To sum up, rehabilitation nursing care contributes to the improvement of hypercoagulable states and the prevention of lower-limb DVT for surgically treated patients with spinal fractures. Moreover, it is effective in relieving pain and swelling of the lower limbs, enhancing quality of

Table 5. Comparison of satisfaction with nursing care between the two groups (n (%))

Group	Satisfied	Basically satisfied	Not satisfied	Satisfaction
Study group (n=50)	25 (50.00)	23 (46.00)	2 (4.00)	48 (96.00)
Control group (n=49)	17 (34.69)	24 (48.98)	8 (16.33)	41 (83.67)
X^2			4.141	4.141
P			0.042	0.042

life and patient satisfaction, and as such it is worthy of clinical promotion.

Disclosure of conflict of interest

None.

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