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Ultrasonographic features and risk factors of postoperative lower limb deep venous thrombosis in patients with lower limb fractures

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Deep venous thrombosis (DVT) has insidious clinical symptoms, and only a few patients suffer from lower limb swelling, tenderness and dorsal flexion pain. We aimed to explore the ultrasonographic features and risk factors of postoperative lower limb DVT in patients with lower limb fractures. Ninety patients with lower limb fractures admitted from January 1st, 2021 to June 30th, 2023 were selected. Color Doppler ultrasonography was performed one month after operation, and the ultrasonographic features were recorded. DVT was diagnosed according to the results of venography, based on which the patients were divided into a DVT group and a non-DVT group. Their basic and treatment-related data were compared. The risk factors for postoperative DVT were screened by multivariate logistic regression analysis. A total of 63 cases were diagnosed with DVT by venography, with a detection rate of 70.00%. A total of 69 cases were diagnosed with DVT by ultrasonography, with a detection rate of 76.67% (P>0.05). The concurrent internal medicine diseases, associated injuries, no preventive measures for thrombosis, operation time ≥2 h, no active or passive exercise after operation, pelvic and proximal femoral fractures, knee fractures and tibiofibular fractures were risk factors for postoperative DVT in patients with lower limb fractures (P<0.05). Ultrasonography is effective for diagnosing postoperative lower limb DVT in patients with lower limb fractures. Related preventive measures should be taken promptly to control the risk factors.

Keywords: Deep venous thrombosis, fractures, lower limb, risk factors, ultrasonography.

INTRODUCTION

Postoperative surgical trauma, long-term immobilization and limited limb movement in patients with lower limb fractures reduce patient's activity, so slow venous blood flow and stasis and local platelet aggregation occur, thus easily triggering lower limb deep vein thrombosis (DVT)[1]. The main symptoms of lower limb DVT are local redness, swelling, fever and pain, and vascular sclerosis is gradually aggravated as the inflammatory symptoms resolve. Venous return is blocked in the case of thrombosis, thus leading to lower limb pain, swelling and difficulty in walking. Hirsh et al.[2] reported that DVT progressed into thrombosis in most cases if not diagnosed and treated promptly, causing sequelae such as limb functional disability and affecting the quality of life for a long time. In severe cases, concurrent pulmonary embolism may occur, making treatment more difficult and even threatening the patient's life, with high mortality. The influencing factors for postoperative lower limb DVT in patients with lower limb fractures are complex, and the primary clinical focus is on prevention and control at present, but no method that can completely cure the sequelae of DVT has been discovered[3]. Therefore, it is necessary to take safe and effective measures to examine and diagnose DVT and to clarify the main risk factors for postoperative DVT in patients with lower limb fractures, which is essential for formulating prevention and control measures in advance.

Previously, venography was mainly used for the diagnosis of DVT due to high accuracy and visual display. Nevertheless, it has some indications and contraindications, as well as some complications, and surgical patients are faced with higher risks and even die in severe cases[4]. Characterized by simple operation, no pain, no trauma, no radiation and repeatability, color Doppler ultrasonography can better reflect the hemodynamic and venous anatomical characteristics in the process of thrombosis[5]. In recent years, ultrasonography has been applied to the diagnosis of DVT[6].

Based on this, the ultrasonographic features of postoperative lower limb DVT in patients with lower

limb fractures and the risk factors for DVT were analyzed in this study, aiming to provide valuable evidence for clinical treatment.

MATERIALS AND METHODS

General data

Ninety patients with lower limb fractures admitted to our hospital from January 1st, 2021 to June 30th, 2023 were selected as subjects. This study was approved by the ethics committee of our hospital, and written informed consent form was obtained from all patients.

The inclusion criteria were as follows: 1) patients clinically diagnosed with lower limb fractures, 2) those who had good mental state and could actively cooperate with the study, and 3) those undergoing venography. The exclusion criteria involved: 1) patients with a history of venous thrombosis, 2) those with a history of vascular surgery, or 3) those complicated with severe cardiac, hepatic or renal dysfunction.

Ultrasonography

Ultrasonography was performed one month after operation using a color Doppler ultrasound diagnostic apparatus (Ningbo Kangda Kennen Medical Technology Co., Ltd., model: KD-Apsaras A400) with a transducer frequency of 5-10 MHz. The femoral and iliac veins were scanned in a supine position, and the posterior tibial and iliac veins were scanned in a prone position. The deep veins of lower limbs were scanned in transverse and longitudinal directions to observe the vascular wall, lumen and surrounding structure, and the size and location of thrombus and lumen embolism were recorded accurately. Diagnostic criteria were as follows[7]: Lumen enlargement, vascular wall thickening and small light spots in the lumen at the site of vascular obstruction, uniform and low echo (acute thrombus), high and irregular echo and no blood flow in the lumen at the thrombus site (subacute and chronic thrombus).

Venography

Venography was performed one month after operation using Artis zee III floor-mounted system (Siemens AG, Germany) with compound meglumine diatrizoate as contrast media. In a supine position, tourniquets were applied at the ankle, supracondylar femur and thigh root. The contrast medium was injected into the superficial vein of foot. Then under fluoroscopy, tourniquets were released in sequence, and deep veins were photographed. Diagnostic criteria were as follows[8]: interruption of deep vein imaging, irregular thin line of contrast medium, and venous filling defect.

Grouping method

According to the results of venography, the patients were divided into a DVT group (n=63) and a non-DVT group (n=27).

Statistical analysis

The measurement data were tested for normality by SPSS26.0 software. The normally distributed measurement data were described by ($x \pm s$), and compared between the two groups by the t-test. The count data were described by [n(%)], and compared by the $\chi 2$ test. The risk factors for postoperative lower limb DVT in patients with lower limb fractures were screened by multivariate logistic regression analysis. $P<0.05$ was considered statistically significant.

RESULTS

Baseline clinical data of all patients

The patients were 25-75 years old, with a mean age of (45.4±6.8) years. There were 32 cases of pelvic and proximal femoral fractures, 25 cases of knee fractures, 17 cases of tibiofibular fractures, 10 cases of ankle fractures, and 6 cases of spinal fractures. Among these patients, 43 cases were aged ≥50 years, and there were 55 males and 35 females. Besides, 46 cases had concurrent internal medicine diseases (cardiovascular, respiratory, gastrointestinal, endocrine, renal, hematologic, infectious, rheumatologic, neurological, allergic and immunologic, dermatologic or oncologic diseases), 37 cases had bone traction, 46 cases had other injuries, 32 cases had D-dimer level of ≥500 μg/L, 33 cases had preventive measures for thrombosis, 43 cases had operation time of ≥2 h, and 42 cases had active and passive exercise after operation.

Results of different examination methods

Sixty-three cases were diagnosed with DVT by venography, with a detection rate of 70.00%. A total of 69 cases were diagnosed with DVT by ultrasonography, with a detection rate of 76.67%. There was no statistically significant difference ($P>0.05$) (Table I).

Occurrence of DVT

According to the results of venography, the patients were divided into a DVT group and a non-DVT group. In the non-DVT group, there was no involvement of both lower limbs. The DVT group included 22 cases of right lower limb DVT (34.92%) and 41 cases of left lower limb DVT (65.08%). The incidence of DVT in the left lower limb was higher than that in the right

lower limb. Acute lower limb DVT occurred in 38 patients (60.32%), and subacute and chronic lower limb DVT in 25 patients (39.68%).

Ultrasonographic features

In the DVT group, acute thrombus displayed uniform and low echo in imaging, and subacute and chronic thrombus displayed high and irregular echo and no blood flow in the lumen at the thrombus site. The vascular wall was rough and thickened. The venous lumen at the thrombus site could not be flattened, and few and even no blood flow signals were displayed in color Doppler flow imaging. When the distal limb was squeezed, no significant change was observed in blood flow frequency in patients with complete vascular obstruction, while patients with partial obstruction showed a delayed decrease in blood flow frequency.

In the non-DVT group, the vascular wall was smooth and thin, the lumen had appropriate size and transparency, and the venous lumen at the thrombus site could be flattened. Blood flow with frequency changes was observed in color Doppler flow imaging. When the distal limb was squeezed, blood flow frequency had more obvious changes.

Incidence of postoperative DVT at different fracture sites

The incidence of postoperative DVT was the highest after pelvic and proximal femoral fractures ($P<0.05$), followed by knee and tibiofibular fractures ($P<0.05$). There was no significant difference in the incidence of postoperative DVT at other fracture sites ($P>0.05$) (Table II).

Basic and treatment-related data of patients

The age, gender, presence or absence of bone traction and D-dimer level were compared between DVT group and non-DVT group ($P>0.05$). It was found that the proportions of patients with concurrent internal medicine diseases, associated injuries, no preventive measures for thrombosis, operation time ≥2 h, and no active and passive exercise after operation in DVT group were higher than those in non-DVT group ($P<0.05$) (Table III).

Table I. — Results of different examination methods [n(%)].

Group	Positive	Negative
Venography	63 (70.00)	27 (30.00)
Ultrasonography	69 (76.67)	21 (23.33)
χ^2	1.023	
P	0.312	

Results of multivariate logistic regression analysis on postoperative lower limb DVT in patients with lower limb fractures

Multivariate logistic regression analysis was performed using postoperative DVT as a dependent variable (Yes=1 and No=2), and statistically significant factors (concurrent internal medicine diseases, associated injuries, no preventive measures for thrombosis, operation time ≥2 h, no active or passive exercise after operation, pelvic and proximal femoral fractures, knee fractures and tibiofibular fractures) as independent variables. Table IV lists the assignment of independent variables. The results revealed that concurrent internal medicine diseases, associated injuries, no preventive measures for thrombosis, operation time ≥2 h, no active or passive exercise after operation, pelvic and proximal femoral fractures, knee fractures and tibiofibular fractures were all risk factors for postoperative DVT in patients with lower limb fractures ($P<0.05$) (Table V and Figure 1).

DISCUSSION

With the accelerated pace of life, the number of patients with lower limb trauma has been increasing. In orthopedics, lower limb fractures are common, and associated injuries, traffic injury and falls are the main inducing factors of fractures[9]. Currently, lower limb fractures are mostly treated by surgery, achieving better results, but patients with lower limb fractures are prone to postoperative DVT[10]. Survey shows that the incidence rate of postoperative DVT in orthopedic patients is as high as 40%-60%. Due to limb injury and surgical wound pain, lower limb activity and lower limb muscle movement are reduced, making lower limb venous return in a stagnant state, and resulting in DVT[11]. DVT is a common disease globally, and the cumulative incidence of DVT increases with aging, i.e., 0.5% at the age of 50 and 3.8% at the age of 80 in men[12]. As shown in incomplete statistics in China, the annual incidence of DVT is 0.5‰ to 1‰[13]. From the above research data, it can be seen that the number of DVT patients is large, so how to reduce the incidence of postoperative DVT in patients with lower limb fractures is one of the clinical problems urgently to be solved.

DVT has insidious clinical symptoms, and only a few patients suffer from lower limb swelling, tenderness and dorsal flexion pain[14]. Since early thrombosis is asymptomatic, it is easy to be ignored, making patients miss the best opportunity for treatment. Lower limb DVT is a common vascular disease, and

Table II. — Incidence of postoperative DVT at different fracture sites [n(%)].

Fracture site	DVT group (n=63)	Non-DVT group (n=27)	χ^2	P
Pelvis and proximal femur	27 (42.86)	5 (18.52)	4.886	0.027
Knee	22 (34.92)	3 (11.11)	5.341	0.021
Tibiofibular	8 (12.70)	9 (33.33)	5.253	0.022
Ankle	4 (6.35)	6 (22.22)	3.348	0.067
Spine	2 (3.17)	4 (14.81)	2.458	0.117

Table III. — Basic and treatment-related data of patients [n(%)].

Group		DVT group (n=63)	Non-DVT group (n=27)	χ^2	P
Age (year)	<50	29 (44.00)	18 (62.50)	3.225	0.073
	≥50	34 (56.00)	9 (37.50)		
Gender	Male	35 (52.00)	20 (52.50)	2.727	0.099
	Female	28 (48.00)	7 (47.50)		
Concurrent internal medicine diseases	No	25 (38.00)	19 (72.50)	7.123	0.008
	Yes	38 (62.00)	8 (27.50)		
Bone traction	No	36 (52.00)	17 (62.50)	0.264	0.607
	Yes	27 (48.00)	10 (37.50)		
Associated injuries	No	24 (36.00)	20 (67.50)	9.791	0.002
	Yes	39 (64.00)	7 (32.50)		
Preventive measures for thrombosis	No	46 (68.00)	11 (40.00)	8.478	0.004
	Yes	17 (32.00)	16 (60.00)		
D-dimer (μg/L)	<500	19 (12.00)	9 (22.50)	0.089	0.766
	≥500	44 (88.00)	18 (77.50)		
Operation time (h)	<2	27 (46.00)	20 (75.00)	7.382	0.007
	≥2	36 (54.00)	7 (25.00)		
Active and passive exercise after operation	No	40 (80.00)	8 (20.00)	8.708	0.003
	Yes	23 (20.00)	19 (80.00)		

Table IV. — Assignment of independent variables.

Independent variable	Description	Assignment
Concurrent internal medicine diseases	Categorical variable	"1"= Yes. "2"= No
Associated injuries	Categorical variable	"1"= Yes. "2"= No
No preventive measures for thrombosis	Categorical variable	"1"= Yes. "2"= No
Operation time ≥2 h	Categorical variable	"1"=≥2. "2"=<2
No active or passive exercise after operation	Categorical variable	"1"= Yes. "2"= No
Pelvic and proximal femoral fractures	Categorical variable	"1"= Yes. "2"= No
Knee fractures	Categorical variable	"1"= Yes. "2"= No
Tibiofibular fractures	Categorical variable	"1"= Yes. "2"= No

early prevention and prompt treatment of thrombosis are important for postoperative recovery[15]. In this study, color Doppler ultrasonography was performed on patients with lower limb fractures. The results showed that postoperative DVT was manifested as low or moderate echo in the lumen of lower limb deep veins, and thrombus echo gradually increased with the progression of disease. Meadway et al.[16] pointed out that color Doppler ultrasonography could also reflect the hemodynamics of the recanalized lower limb deep vein, and the presence or absence of blood flow reflux disorder could be determined by observing deep vein reflux, with higher diagnostic accuracy.

DVT is a common complication of lower limb fractures, and patients with lower limb fractures + DVT are highly prone to sequelae. In severe cases,

Table V. — Results of multivariate logistic regression analysis on postoperative lower limb DVT in patients with lower limb fractures.

Item	B	Standard error	Wald	Degree of freedom	Significance	Exp(B)	Exp(B)95% CI	
							Lower limit	Upper limit
Concurrent internal medicine diseases	-1.284	0.494	6.755	1	0.009	0.277	0.105	0.729
Associated injuries	-1.535	0.510	9.061	1	0.003	0.215	0.079	0.585
No preventive measures for thrombosis	1.370	0.484	8.023	1	0.005	3.936	1.525	10.157
Operation time ≥2 h	-1.338	0.508	6.943	1	0.008	0.263	0.097	0.710
No active or passive exercise after operation	1.418	0.496	8.174	1	0.004	4.130	1.562	10.921
Pelvic and proximal femoral fractures	-1.194	0.557	4.594	1	0.032	0.303	0.102	0.903
Knee fractures	-1.457	0.667	4.772	1	0.029	0.233	0.063	0.861
Tibiofibular fractures	1.235	0.557	4.920	1	0.027	3.437	1.155	10.234

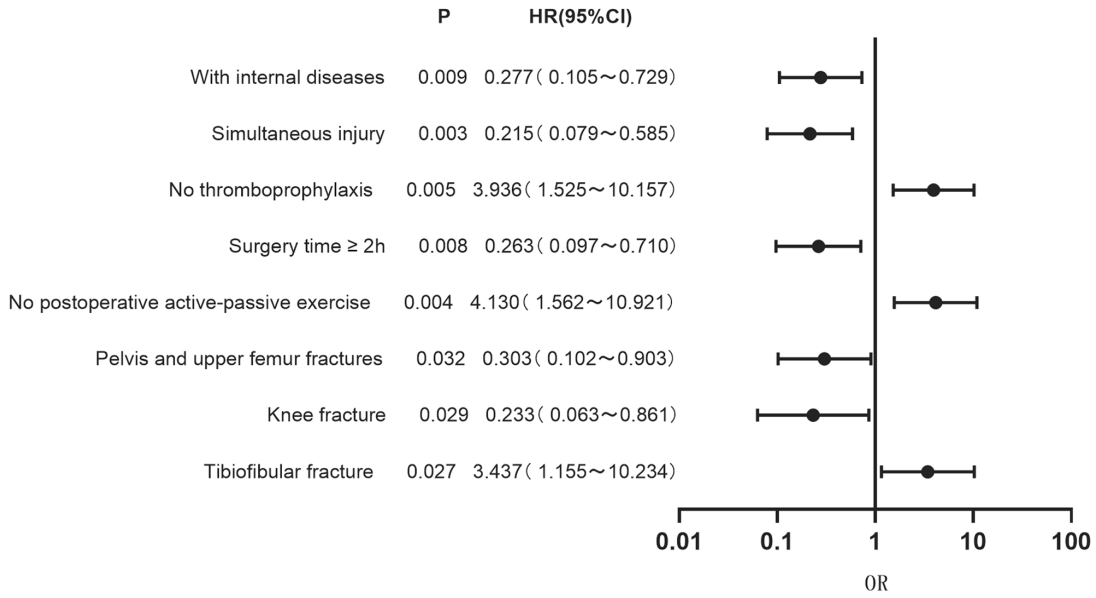

Fig. 1 — Forest plot of clinical characteristics based on multivariate logistic regression analysis.

pulmonary embolism is caused due to thrombus shedding, which increases the risk of death and seriously affects the post-discharge quality of survival and living ability[17]. There is still a lack of radical treatment means for the sequelae of DVT, so it is crucial to explore the risk factors for postoperative lower limb DVT in patients with lower limb fractures and develop corresponding prevention and control methods for reducing the incidence of postoperative DVT. In this study, the proportions of patients with concurrent internal medicine diseases, associated injuries, no preventive measures for thrombosis, operation time ≥2 h, and no active and passive exercise after operation in DVT group were higher than those in non-DVT group, suggesting that postoperative DVT in patients with lower limb fractures is possibly associated with presence or absence of internal medicine diseases, associated injuries, preventive measures for thrombosis and active and passive exercise after operation, and operation time. Furthermore, the results of multivariate logistic regression analysis showed that concurrent internal medicine diseases, associated injuries, no preventive measures for thrombosis, operation time ≥2 h, and no active or passive exercise after operation were all risk factors for postoperative DVT in patients with lower limb fractures. It has been shown that concurrent internal medicine diseases such as hyperlipidemia and hypertension can make the blood hypercoagulable and are a high-risk factor for lower limb fractures + DVT[18], consistent with the results in this study. Patients with multiple injuries have a significantly higher risk of DVT than those with single injuries, also suggesting that associated injury is an independent risk factor for lower limb fractures + DVT. In this study, absence of preventive measures for thrombosis was one of the important risk factors for lower limb DVT, but preventive measures for thrombosis were indeed adopted in 32% of patients

in DVT group, indicating that other protection work is required in addition to prevention of thrombosis. Besides, the duration of anesthetic use is prolonged with the increase in operation time, and long-term traumatic irritation can cause a systemic inflammatory response, resulting in DVT. It has been verified that normal individuals will have slow blood flow, erythrocyte aggregation, and increased whole blood viscosity after 5 d of bed rest[19,20]. Due to postoperative long-term immobilization, patients with lower limb fractures cannot exercise, thus causing muscle atrophy, slow blood flow, blood hypercoagulability and ultimately DVT. In this study, fractures at different sites were also an influencing factor for lower limb DVT, i.e., the incidence of lower limb DVT was the highest after pelvic and proximal femoral factures, followed by knee fractures and tibiofibular fractures, ankle fractures and spinal fractures. Thigh fractures usually caused by traffic accidents or crush are severe, and the distal femur is densely vascularized, so vascular intima may be damaged, which, combined with post-trauma local swelling, compression, immobilization and blood flow stasis in the lower limb, results in DVT. Therefore, the risk of DVT after thigh fractures is higher than that after leg fractures. In addition, the occurrence of lower limb DVT is correlated with the age of patients, i.e., and the older the patient, the higher the risk of DVT[21]. In this study, patients with lower limb fractures aged ≥50 had a higher risk of DVT than those aged <50, but there was no significant difference in the patient's age between DVT group and non-DVT group, possibly because of the small sample size.

Nevertheless, this study is limited. The sample size is small, so the results may have bias. Hence, our findings need to verified in larger cohorts.

CONCLUSION

In conclusion, ultrasonography is effective in the diagnosis of postoperative lower limb DVT in patients with lower limb fractures, characterized by simple operation, little harm and high diagnostic accuracy. The risk factors for postoperative lower limb DVT in patients with lower limb fractures are diverse, so they must be controlled by timely and effective prevention and control measures.

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