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Effect of different balloon pressure band compression regimens on thrombolysis and lower limb venous blood flow velocity in patients undergoing anterograde thrombolysis via the superficial dorsalis pedis vein

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Abstract

Objective To evaluate the comparative effectiveness of two distinct balloon pressure band compression regimens on the treatment outcomes for deep vein thrombosis (DVT) and venous blood flow velocity in the lower limbs of patients undergoing anterograde thrombolysis through the superficial dorsalis pedis vein.

Methods A total of 42 patients diagnosed with DVT were enrolled in the randomized controlled trial. Patients in the control group received balloon pressure band compression positioned 15 cm above the bony landmark of the medial malleolus of the affected limb, with continuous inflation and deflation. On the basis of the control group, a balloon pressure band was also used 15 cm above the bony landmark of the medial malleolus and 10 cm below the midpoint of the patella in the affected limb in experimental group, with rotational inflation at these two sites. The thrombolysis effects and venous blood flow velocity of the lower extremities were compared between the two groups.

Results The differences in limb circumference and Marder scores of patients in the experimental group were significantly lower than those in the control group, while the detumescence rate and venous patency rate of the affected limbs in the experimental group were significantly higher than those in the control group ($P<0.05$). After 30 and 60 min of thrombolysis, femoral and popliteal vein blood flow velocities in the experimental group were significantly higher than those in the control group ($P<0.05$). After 45 min post-thrombolysis, the femoral vein blood flow velocity in the experimental group remained significantly higher than that in the control group ($P<0.05$), though no significant difference was observed in the popliteal vein blood flow velocity ($P>0.05$).

Conclusion In this study, alternating balloon pressure band compression applied at 15 cm above the bony marker of the medial malleolus and 10 cm below the patellar midpoint to block superficial venous blood flow was found

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to enhance thrombolysis efficacy and significantly improve venous blood flow velocity in the lower extremities among patients with DVT.

Keywords Balloon pressure band, Deep vein thrombosis, Therapeutic thrombolysis, Venous thromboembolism

Introduction

Deep vein thrombosis (DVT) is characterized by the obstruction of blood vessels due to thrombus formation within the deep venous system resulting from a combination of abnormal blood coagulation factors. DVT presents an important clinical challenge because of its high morbidity, disability, and mortality rates [1]. With risk factors becoming increasingly prevalent, the incidence of DVT has shown a marked upward trend in recent years, with reported rates as high as 0.14%–0.16% [2, 3]. Detachment of thrombi in DVT can lead to potential life-threatening complications such as pulmonary embolism (PE) and the development of post-thrombotic syndrome (PTS). Therefore, timely and effective anticoagulation therapy is crucial to achieve complete thrombus dissolution and reduce these risks.

It has been emphasized in the *Expert Consensus on the Endovascular Treatment for Deep Venous Post-Thrombotic Syndrome of Lower Extremity* (2023) that, in addition to prioritizing therapeutic efficacy, other factors such as safety, timeliness, and the chronic nature of the condition must be taken into consideration in the management of DVT [4]. The commonly used thrombolytic therapies in clinical practice include systemic thrombolysis, deep venous thrombolysis, and catheter-directed thrombolysis (CDT) [5, 6]. Systemic thrombolytic therapy has been shown to be less effective than CDT in reducing lower extremity swelling and thrombus burden, and it carries a greater risk of complications and a higher incidence of PTS [7]. Dorsalis pedis vein thrombolysis (DPVT) offers an effective alternative, especially when CDT is contraindicated or unsuccessful. DPVT is associated with a lower risk of bleeding and is relatively easy to perform [8–10]. The theoretical basis of DPVT lies in leveraging the connections between the deep and superficial veins; by blocking the superficial veins, thrombolytic agents administered via the dorsalis pedis vein can be directed to the deep vein thrombosis site, thereby enhancing drug delivery to the target site and improving thrombolytic efficacy.

The selection of an appropriate and effective method to block the blood flow of superficial veins is critical to ensuring accurate and sufficient delivery of thrombolytic agents into the deep venous system, thereby optimizing treatment outcomes. Studies have shown that favorable thrombolytic effects can be achieved by using limb pressure bands to obstruct superficial venous blood flow at various locations in the lower limbs [11–13]. However, current protocols typically focus on occluding a single superficial venous vein in the lower leg.

In this study, the aim was to investigate the clinical impact of different superficial venous blood flow blocking regimens in the management of lower extremity DVT, as detailed below.

Sample and methods

Study participants

Sources and grouping of medical records

A total of 42 DVT patients diagnosed with DVT and treated at the Second Affiliated Hospital of Nantong University, Cina, were selected for the study. Participants were divided into two groups: the control group that consisted of 20 patients admitted between January 2023 and August 2023, and the experimental group comprising 22 patients admitted between September 2023 and March 2024.

Inclusion criteria

Participants who fulfilled the following criteria were included in the study: (1) age < 75 years; (2) disease duration of ≤ 28 days; (3) presence of unilateral limb swelling, with a diagnosis of DVT confirmed by digital subtraction angiography (DSA) in accordance with the criteria set forth by the 4th Academic Conference of the Peripheral Vascular Disease Professional Committee of the Chinese Association of Integrative Medicine in October 1995 [14]; (4) treatment with DPVT drugs for a duration of 7–10 days [15], with a minimum follow-up period of 3 months; and (5) written informed consent obtained from all patients for their participation in this study.

Exclusion criteria

Patients with the following conditions were excluded from the study: (1) a history of gastrointestinal bleeding, cerebrovascular hemorrhage, and/or surgery within the past three months; (2) acute or chronic inflammation, skin damage, or allergic reactions affecting the affected limb; (3) coagulation disorders; (4) refractory hypertension (blood pressure > 180/100 mmHg) [16].

Sample size calculation

The aim of this randomized controlled study was to analyze the impact of two distinct balloon pressure band compression regimens on the efficacy of thrombolysis and lower limb blood flow velocity in patients undergoing anterograde thrombolysis via the superficial dorsalis pedis vein. Sample size estimation was performed using a formula comparing sample means, with μα and μβ representing the values corresponding to a test significance level (α) of 0.05 and a type II error probability (β) of 0.2, yielding $\mu_\alpha = 1.960$ and $\mu_\beta = 0.842$. The difference in venous thrombus clearance rate was denoted by δ, with previous research [12] indicating a mean difference of 13 before and after intervention. Accordingly, δ was set to 13, and the estimated standard deviation (σ) was 14.1. Based on the formula: $N = \left[\frac{2(\mu_\alpha + \mu_\beta)\sigma}{\delta}\right]^2$, the required minimum sample size was calculated as 36. Accounting for an anticipated loss to follow-up rate of 15%, the final sample size required was 42 cases.

The study was approved by the Hospital Ethics Committee.

Research methods

Instruments and equipment

1) A specialized sphygmomanometer for thrombolysis (model XJ-B, Jiangsu Yuanyan Medical Equipment Co., Ltd.) with a cuff length of 70 cm, balloon length of 40 cm, and a balloon width of 7.5 cm. 2) A color Doppler ultrasonic detector (Mindray DC-26, Shenzhen Mindray Bio-Medical Electronics Co., Ltd., Shenzhen, Guangdong). 3) A computerized infusion pump (model AJ5808, Shanghai Angel Electronic Equipment Co., Ltd.). 4) a reusable vena cava filter (466-F210AF, Cordis [Shanghai] Medical Devices Co., Ltd.).

Low-dose thrombolytic therapy

In both patient groups, indwelling needles were inserted into the superficial dorsalis pedis vein, and a computerized infusion pump was used to continuously administer a low-dose thrombolytic drug regimen. The thrombolytic solution consisted of 100 ml of 0.9% sodium chloride solution mixed with 200,000 U/d of urokinase per day, delivered at a flow rate of 50 ml/h. In addition to thrombolytic therapy, all patients received a subcutaneous injection of nadroparin (Nasaichang, 4100 U every 12 h, Nanjing King-Friend Biochemical Pharmaceutical Co., Ltd.) as an anticoagulant. Coagulation parameters were monitored daily throughout the intravenous thrombolytic therapy.

Thrombolytic therapy was discontinued under the following conditions: (1) resolution of limb swelling and pain, with venography confirming complete thrombus dissolution, restored blood flow, and unobstructed venous lumen; (2) occurrence of treatment-related complications such as venous inflammation or bleeding; (3) no significant improvement in symptoms such as swelling and pain of the affected limb or no change in intravenous thrombosis on angiography after five consecutive days of treatment; (4) fibrinogen levels dropping to < 1.0 g/L [17, 18].

Methods of blocking superficial venous blood flow

The blood flow of superficial veins of patients in both groups was obstructed using a specialized thrombolysis sphygmomanometer. The occlusion pressure was adjusted to achieve complete disappearance of superficial vein imaging via Digital Subtraction Angiography (DSA) while ensuring complete visualization of deep veins (Figs. 1 and 2). Since each individual's veins are distinct, the required pressures are also different, making the approach personalized.

(1) Control group: Prior to thrombolysis, the lower edge of the cuff of the special sphygmomanometer for thrombolysis was placed 15 cm above the highest bony landmark of the medial malleolus, and the cuff was wrapped around the limb, maintaining a space sufficient to accommodate one finger. The rotational compression protocol was as follows: after initiation of thrombolysis, alternating cycles of inflation and deflation were performed for 15 min, followed by a 15-min pause, continuously repeated until the completion of the thrombolytic therapy.
(2) Experimental group: Before initiating superficial venous thrombolysis therapy, a specialized thrombolysis sphygmomanometer was used to apply compression alternatively above the ankle and below the knee. The procedure involved positioning and applying pressure above the ankle as per the same parameters used in the control group. Additionally, the upper edge of the pressure band below the knee was placed 10 cm below the midpoint of the patella, and the cuff was wrapped around the limb, ensuring a one-finger space. The rotational compression protocol involved inflating the pressure band above the ankle for 15 min, followed by relaxing the pressure. Immediately after, the pressure band below the knee was inflated for 15 min, then relaxed. This cycle of alternating compression was repeated until the conclusion of the thrombotic treatment.

Quality control

(1) Preparation of testing instruments: The same model of infusion pump, specialized thrombolysis sphygmomanometer, and color Doppler ultrasonic detector were used in all tests. The performance of all instruments and equipment was verified to be optimal before use. (2) Data

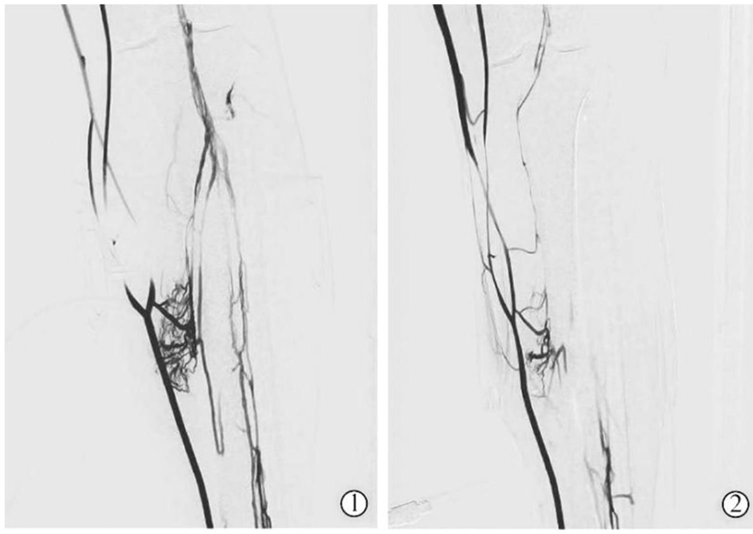

Fig. 1 The deep venous opacification of the lower limbs under pressure via balloon pressure band. The optimal pressure for venous occlusion is determined based on the opacification status of the deep veins

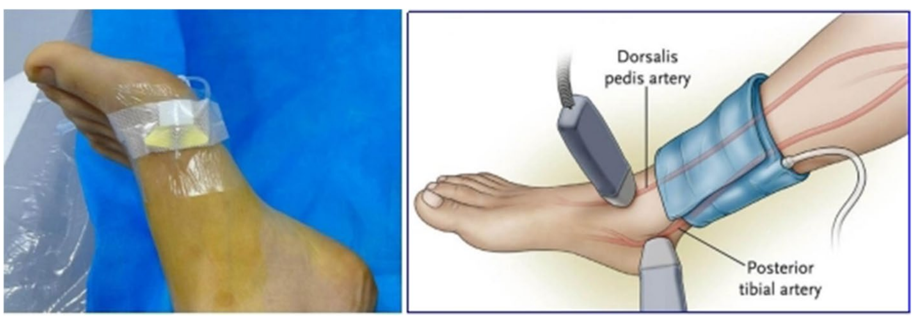

Fig. 2 Cannulation of the dorsal superficial vein of the foot (left); balloon pressure band (right)

collection stage: The intraoperative procedures for all patients were consistently performed by the same group of doctors and catheter room nurses. Data collection during procedures was carried out by a single designated nurse from the catheter room. The nursing staff of the ward underwent standardized training from physicians on the correct use of the thrombolysis sphygmomanometer and compression protocols to ensure uniformity in nursing procedures and techniques. Measurements of venous blood flow velocity were conducted by the same sonographer for all patients. (3) Data verification and entry: Data entry was conducted independently by two staff members and cross-verified to ensure the accuracy and integrity of the data entered.

Evaluation procedure

(1) Limb circumference difference and detumescence rate: The patient was positioned supine, and the attending nurse placed the upper edge of a measuring tape 10 cm below the midpoint of the patella every day. The measuring tape was wrapped around the leg in a complete circle, and the circumference of the leg was measured. The difference in limb circumference was defined as the difference between the circumference of the affected limb and the circumference of the healthy limb. The limb detumescence rate was calculated as follows:

$$\text{Limb detumescence rate} = (\text{Difference in limb circumference before thrombolysis} - \text{Difference in limb circumference after thrombolysis}) / \text{Difference in limb circumference before thrombolysis} \times 100\%.$$

(2) Marder score and limb venous patency rate: The Marder score, a widely accepted measure proposed

by Professor Marder in 1977, was used to quantify the extent of intravascular thromboembolism in patients with DVT [19]. Each patient underwent a minimum of two evaluations: the first was during venography at the time of admission, and the second was upon review of venography before removal of the thrombolytic catheter. This score was determined by two experienced interventional physicians (with over five years of experience), who evaluated images uploaded to the hospital's Picture Archiving and Communication System (PACS) [19].

The venous vascular patency rate was calculated as follows [20]:

$$\text{Venous vascular patency rate} = (\text{Marder score before thrombolysis} - \text{Marder score after thrombolysis}) / \text{Marder score before thrombolysis} \times 100\%.$$

(3) Venous blood flow velocity of lower extremities: Blood flow measurements of the femoral and popliteal veins were conducted using the Mindray DC-26 color Doppler ultrasound detector with a 5–12 MHz probe. The femoral vein, located in the groin, is positioned obliquely medial to the femoral artery, while the popliteal vein is located in the popliteal fossa and runs parallel to the popliteal artery. After identifying the measurement site, markings were made for consistency across repeated assessments. Blood flow velocities in the femoral and popliteal veins were recorded before thrombolysis (baseline) and at 30 min, 45 min, and 60 min post-thrombolysis.

Statistical analysis

SPSS 22.0 statistical software was used for data analysis. Measurement data conforming to a normal distribution were represented using the mean ± standard deviation ($\bar{x} \pm s$). An independent samples t-test or analysis of variance (ANOVA) was used for comparison between groups, while the paired t-test was used for within-group comparisons of pre- and post-intervention. Categorical data were represented as the number of cases and percentages (%), with comparisons made using the x^2 test. For repeatedly measured data, repeated measures ANOVA was used to evaluate the effects of the intervention across different time points. The difference was considered statistically significant at a P value < 0.05.

Results

Comparison of general data between the two groups of patients

There were no significant differences in basic characteristics such as age, sex, body mass index (BMI), thrombus location, duration of the disease, and comorbidities between patients in the control and experimental groups ($P > 0.05$) (Table 1).

Comparison of the pre- and post-thrombolysis limb circumference difference and detumescence rates between the two groups of patients

The difference in the circumference of the affected limb was compared before and after thrombolysis in both groups. There was no significant difference in the overall circumference difference of the affected limb between the two groups of patients before thrombolysis ($P > 0.05$). Post-thrombolysis, there was a statistically significant difference in the overall score of circumference difference of the affected limb ($P < 0.001$) (Table 2). The detumescence rate of the affected limb was significantly higher in the experimental group compared to the control group ($P < 0.001$) (Table 3).

Comparison of the pre- and post-thrombolysis Marder score and venous patency rates of the affected limb between the two groups of patients

Analysis of the Marder score and venous patency rates of the affected limb in the two groups of patients revealed no significant differences in these two parameters between the two groups of patients before thrombolytic therapy ($P > 0.05$). Post-thrombolysis, there were significant differences between the groups, with both the Marder score and venous patency rate improving significantly in the experimental group compared to the control group ($P < 0.001$) (Tables 4 and 5).

Comparison of the post-thrombolysis blood flow velocity of the femoral and popliteal veins between the two groups of patients

Post-thrombolysis blood flow velocities of the femoral vein of the affected limb at 30, 45, and 60 min were all significantly faster in the experimental group than those in the control group (all $P < 0.05$). Similarly, the blood flow velocities of the popliteal vein of the affected limb at 30 and 60 min after thrombolysis were all significantly higher in the experimental group than those in the control group (all $P < 0.05$). However, there was no statistically significant difference in the popliteal vein blood flow velocity of the affected limb at 45 min post-thrombolysis between the two groups ($P > 0.05$) (Tables 6 and 7).

Table 1 Comparison of the general data of patients between the two groups

Variables	Experimental group ($n = 22$)	Control group ($n = 20$)	Test statistics	*P* value
Age ($\bar{x} \pm$ s)	24.73 ± 3.28	24.68 ± 3.79	-1.442[a]	0.149
Sex [n (%)]			0.500[4)]	0.479
Male	6(27.3)	3(15.0)		
Female	16(72.7)	17(85%)		
Body mass index ($\bar{x} \pm$s)	23.31 ± 3.53	23.72 ± 3.86	0.383[a]	0.826
Thrombus site [n (%)]			0.165[b]	0.835
Femoral vein	6(27.3)	5(25.0)		
Popliteal vein	7(31.8)	6(30.0)		
External iliac vein	3(13.6)	2(10.0)		
Common iliac vein	2(9.1)	3(15.0)		
Interscalene venous plexus of the lower extremities	4(18.2)	4(20.0)		
Duration of the disease [n (%)]			0.411[b]	0.331
2–5 days	7(31.8)	8(40.0)		
6–9 days	8(36.4)	6(30.0)		
10–13 days	7(31.8)	6(30.0)		
Comorbidity [n (%)]			1.670[b]	0.564
Diabetes mellitus	6(27.3)	5(25.0)		
Hypertension	7(31.8)	6(30.0)		
Autoimmune diseases	1(4.5)	0(0.0)		
Tumor	6(27.3)	7(35.0)		
Affected limb [n (%)]			0.073[b]	0.788
Left limb	18(81.8)	15(75.0)		
Right limb	4(18.2)	5(25.0)		
Thrombus type [n (%)]			0.241[b]	0.440
Central type DVT	10(45.5)	7(35.0)		
Mixed type DVT	12(54.5)	13(65.0)		
Additional interventions [n (%)]			3.405[b]	0.064
Iliac vein balloon dilation	2(9.1)	1(5.0)		
Iliac vein stent implantation	1(4.5)	0(0.0)		
Balloon dilation and stents	2(9.1)	1(5.0)		
No intervention	17(77.3)	18(90.0)		

All $P > 0.05$

[a] t value

[b] x^2 value

Table 2 Comparison of the pre- and post-thrombolysis limb circumference difference between the two groups (cm, $\bar{x} \pm$ s)

Groups	Pre-thrombolysis	Post-thrombolysis	*t* value	*P* value
Control group ($n = 20$)	6.34 ± 0.20	3.42 ± 0.11	15.603	< 0.001
Experimental group ($n = 22$)	6.29 ± 0.17	2.31 ± 0.13	19.412	< 0.001
t value	0.057	34.11		
P value	0.37	< 0.001		

Table 3 Comparison of pre- and post-thrombolysis detumescence rate of the affected limb between the two groups (%, $\bar{x}\pm$ s)

Groups	Detumescence rate of the affected limb (%) ($\bar{x}\pm$ s)
Control group ($n=20$)	49.64 ± 1.95
Experimental group ($n=22$)	59.44 ± 2.09
t value	1.606
P value	0.041

Table 5 Comparison of pre- and post-thrombolysis venous patency rate ($\bar{x}\pm$ s) of the affected limb between the two groups

Groups	Venous patency rate of lower extremities (%)
Control group ($n=20$)	49.72 ± 2.90
Experimental group ($n=22$)	66.11 ± 1.83
t value	1.232
P value	0.023

Discussion

The rotational inflation compression regimen of the balloon pressure band at two sites improved the thrombolytic effect in patients undergoing anterograde thrombolysis for the lower limb via the superficial dorsalis pedis vein

The key to thrombolytic therapy is the prompt and effective restoration of blood flow while preserving normal valve function. Therefore, the choice of appropriate interventional methods and drug administration routes is crucial [21]. Continuous infusion of low-dose thrombolytic agents through an indwelling needle in the superficial dorsalis pedis vein is one of the effective methods for the treatment of DVT in the lower extremities [22]. The vascular architecture of the lower leg features multiple communicating branches between the deep and superficial veins, particularly concentrated in the lower extremities. The connecting branches between the medial and lateral malleolus regions are especially vital, followed by Boyd's vein [23]. The presence of these abundant perforating veins, which link deep vessels such as the iliac and femoral veins located in the deep fascia with the more superficial network located in the superficial fascia, supports efficient drug distribution from the superficial administration site to deeper thrombosis locations [23].

Yan et al. [12] demonstrated that a rotational inflation-deflation approach wherein limb pressure bands were inflated for 15 min at specific sites (15 cm above the medial malleolus' bony mark) and then deflated had better outcomes in terms of limb detumescence, thrombus clearance, and patient comfort compared to traditional localized tourniquet applications. Using the anatomical basis of communicating branches in the lower legs, this research team noted that optimal deep vein perfusion occurs when the superficial venous flow is selectively blocked through rotational sphygmomanometer compression with the cuff placed 10 cm below the lower edge of the patella and 15 cm above the proximal end of the medial malleolus joint. This approach ensures a higher concentration of thrombolytic drugs at the thrombotic site, enhancing the thrombolytic effect.

In the current study, to optimize compression efficacy, balloon pressure band settings were established based on DSA findings, confirming that superficial vein imaging disappears while deep vein development is maximized. This pressure range, tailored to avoid patient discomfort, yielded significant improvements, as evidenced by lower circumference differences and Marder scores of the affected limb in the experimental group compared to the control group, alongside higher detumescence rates and improved venous patency in the affected limb ($P<0.05$).

Table 4 Comparison of pre- and post-thrombolysis Marder scores between the two groups

Groups	Pre-thrombolysis	Post-thrombolysis	*t* value	*P* value
Control group ($n=20$)	27.83 ± 0.64	9.48 ± 0.58	19.61	< 0.001
Experimental group ($n=22$)	27.82 ± 0.52	4.58 ± 0.41	24.56	< 0.001
t value	0.72	67.65		
P value	0.49	< 0.001		

The rotational inflation compression regimen of the balloon pressure band at two sites improved the blood flow velocity index of the affected limb in patients undergoing anterograde thrombolysis through the superficial dorsalis pedis vein

In this study, patients in the experimental group were treated with the rotational inflation compression regimen of the balloon pressure band at two sites, involving rotational inflation of a pressure band for durations of 30, 45, and 60 min. The results revealed significantly increased blood flow velocities of the femoral vein of the affected limb compared to the control group, highlighting the efficacy of the pressure band compression regimen in improving lower limb venous blood flow, mirroring the principles underpinning pneumatic therapeutic devices for lower limbs. Although the intervals in this regimen were longer, the blood flow velocity of the lower limbs was observed to be enhanced, thereby preventing the formation of fresh venous thrombi.

Table 6 Changes in the femoral vein blood flow velocity indexes of the affected limb at different time points between the two groups (cm/s, $\bar{x}\pm$ s)

Groups	Pre-thrombolysis	30 min post-thrombolysis	45 min post-thrombolysis	60 min post-thrombolysis	*F* value	*P* value
Control group (*n* = 20)	20.34 ± 1.23	23.23 ± 1.51	26.29 ± 1.14	27.37 ± 0.78	51.67	< 0.001
Experimental group (*n* = 22)	21.01 ± 1.19	25.40 ± 2.16	28.45 ± 2.01	30.49 ± 1.28		
t value	-0.231	-3.432	-2.656	-4.763		
P value	0.816	0.001	0.007	< 0.001		

$F_{\text{between-group}} = 44.347$, $P_{\text{between-group}} = 0.006$; $F_{\text{between-group}} = 5.323$, $P_{\text{cross}} = 0.008$

Table 7 Changes in the popliteal vein blood flow velocity indexes of the affected limb at different time points between the two groups (cm/s, $\bar{x}\pm$ s)

Groups	Pre-thrombolysis	30 min post-thrombolysis	45 min post-thrombolysis	60 min post-thrombolysis	*F* value	*P* value
Control group (*n* = 20)	15.63 ± 1.11	17.39 ± 0.95	18.76 ± 0.73	19.58 ± 1.11	39.019	< 0.001
Experimental group (*n* = 22)	15.17 ± 1.32	20.01 ± 1.71	18.85 ± 1.16	23.65 ± 0.23		
t value	0.995	-3.237	-1.511	-3.495		
P value	0.345	0.015	0.195	< 0.001		

$F_{\text{between-group}} = 2.323$, $P_{\text{between-group}} = 0.207$; $F_{\text{between-group}} = 0.611$, $P_{\text{cross}} = 0.515$

Another finding in this study was that the popliteal vein blood flow velocity in the affected limb among patients in the experimental group significantly increased with applying rotational inflation and compression for 30 and 60 min at two sites than pre-thrombolysis levels, and the difference was statistically significant when compared with the control group (all $P < 0.05$). However, at the 45-min mark, the popliteal vein blood flow velocity in the affected limb was increased in both groups of patients compared to pre-thrombolysis levels, but the difference between the experimental and the control groups was not significant (all $P > 0.05$). This may be attributable to the specific timing of the compression regimen: at 30 and 60 min, the compression below the knee had just concluded, thereby exerting a proximal influence on the popliteal vein. Conversely, at 45 min, compression was localized above the ankle, likely placing the popliteal vein outside its immediate range of influence.

The study findings suggest that the superior thrombolytic effect observed in the experimental group may be closely linked to increased blood flow velocity during drug administration via the superficial dorsalis pedis vein. By accelerating blood flow, this regimen improves drug delivery to the thrombus site, enhancing the interaction between the drug and the thrombus and achieving a better thrombolytic effect.

Conclusion

In conclusion, blocking the blood flow of the superficial veins of the lower extremities with a balloon pressure band during intraoperative venography is recommended while accurately recording the blocking pressure value for use in compression during subsequent thrombolysis therapy. For continuous low-dose anterograde thrombolysis via an infusion pump through the superficial dorsalis pedis vein, rotational use of balloon pressure bands at 10 cm below the lower edge of the patella and 15 cm above the proximal end of the medial malleolus proved effective in this study. This approach improved blood flow velocity in the lower extremities and yielded better thrombolytic outcomes. However, as a single-center study, the findings have certain inherent limitations and may lack broad authority. Future research, including multi-center investigations with expanded sample sizes, is needed to validate these findings.

Abbreviations

DVT Deep vein thrombosis
PE Pulmonary embolism
PTS Post-thrombosis syndrome
CDT Catheter directed thrombolysis
DPVT Dorsalis Pedis Vein Thrombosis
PACS Picture archiving and communication system
DSA Digital Subtraction Angiography

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Authors' contributions
Conception and design of the research: Baihong Cui, Li Sun Acquisition of data: Zhiyan Cao, Jia Zhao Analysis and interpretation of the data: Haiyan Gu, Jianan Zhou Statistical analysis: Baihong Cui, Zhiyan Cao Obtaining financing: Baihong Cui, Haiyan Gu, Jianan Zhou Writing of the manuscript: Li Sun, Haiyan Gu Critical revision of the manuscript for intellectual content: Zhiyan Cao, Jia Zhao All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Data availability
The datasets generated and/or analysed during the current study are not publicly available but are available from the corresponding author (Li Sun) on reasonable request.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Affiliated Hospital 2 of Nantong University (2024KT572). A written informed consent was obtained from all participants.

Consent for publication
Consent for publication was obtained from every individual whose data are included in this manuscript.

Competing interests
The authors declare no competing interests.

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