ORIGINAL RESEARCH

Application of Subpatellar Venous Catheter Thrombolysis in Early Acute Lower Extremity Deep Vein Thrombosis

Jun Li, MM; Hongqi Guo, BM; Man Li, BM; Wenhong Gao, BM; Yuchan Chen, MM

ABSTRACT

Objective • To compare the effectiveness and safety of intravenous thrombolysis via the subpatellar vein versus the conventional popliteal vein approach in patients with early acute deep venous thrombosis (DVT) of the lower extremities.

Methods • This study included 160 early-stage acute lower extremity DVT patients at our hospital from January 2020 to October 2023, randomly assigned to two groups using sealed envelopes. The control group underwent catheter-directed thrombolysis via the popliteal vein, while the study group received thrombolysis via the subpatellar vein. Surgical parameters, limb circumferences, blood parameters, vein patency, and adverse reactions were evaluated.

Results • The study group had longer surgery and X-ray times, as well as a lower urokinase dose compared to the control group ($P < .05$), with no significant difference in thrombolysis time ($P > .05$). Thigh and calf circumferences and edema rates didn't significantly change before and after thrombolysis in both groups ($P > .05$). Hematological parameters, including PT, INR, APTT, FIB, TT, and D-D levels, remained similar between the two groups before and after thrombolysis ($P > .05$). However, after thrombolysis, both groups showed increased PT, INR, APTT, and TT levels and decreased FIB and D-D levels compared to before thrombolysis ($P < .05$). Porter scores showed no significant differences between the two groups before thrombolysis ($P > .05$), but after thrombolysis, both groups had reduced Porter scores, with the study group showing a more pronounced decrease ($P < .05$). Additionally, the study group had a higher vein patency rate and GCQ score than the control group ($P < .05$). Adverse reactions occurred at a similar rate in both groups ($P > .05$).

Conclusion • Subpatellar vein catheter-directed thrombolysis offers a safe and more effective alternative to traditional popliteal vein approaches for early acute DVT of the lower extremities, improving outcomes such as vein patency and reducing the need for urokinase. (*Altern Ther Health Med.* [E-pub ahead of print.])

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INTRODUCTION

Deep Vein Thrombosis (DVT) presents a significant risk of morbidity and mortality, particularly when untreated or inadequately managed. Interventional thrombolysis, including catheter-directed thrombolysis (CDT),[1] has emerged as a promising approach for treating DVT by directly delivering thrombolytic agents to the site of the clot,[2] thereby accelerating its dissolution and potentially preventing long-term complications such as Post-Thrombotic Syndrome (PTS).[3] While various interventional thrombolysis techniques exist, including systemic thrombolysis, mechanical thrombolysis, and ultrasound-guided thrombolysis, CDT offers a targeted and minimally invasive approach with potential advantages in efficacy and safety.

In CDT, the choice of catheter insertion route significantly impacts treatment outcomes. The most common pathways encountered in clinical practice are via the popliteal and femoral veins.[4] The selection between these pathways lacks definitive guidelines, leaving clinicians to decide based on individual patient factors and institutional practices. However, the anatomical differences between these routes, along with potential variations in efficacy and safety, underscore the need for a direct comparison to inform evidence-based decision-making.

Interventional thrombolysis is a treatment method used for thrombus-related conditions, particularly effective in managing deep vein thrombosis (DVT) and other vascular obstruction situations. The primary goal of this treatment approach is to directly deliver thrombolytic agents to the site of the clot to accelerate its dissolution. Several main types of interventional thrombolysis include systemic thrombolysis, local thrombolysis, catheter-directed thrombolysis (CDT), mechanical thrombolysis, and ultrasound-guided thrombolysis. Each treatment method has specific indications and risks, and the choice of which treatment approach to use depends on the patient's specific condition, the location and size of the thrombus, and the patient's tolerance to thrombolytic drugs.

Among these methods, Catheter-Directed Thrombolysis (CDT) involves the insertion of a thrombolysis catheter directly into the affected vascular area, followed by continuous infusion of thrombolytic drugs such as urokinase to dissolve the thrombus.[5] While CDT offers various catheter insertion routes, the selection between popliteal vein and femoral vein pathways is more commonly encountered in clinical practice. However, it is essential to note that different catheter insertion pathways may yield varying treatment outcomes,[6] and currently, there are no definitive guidelines guiding the choice of CDT catheter insertion routes. Therefore, this study aims to compare the efficacy of catheter-directed thrombolysis using the popliteal and femoral vein pathways in treating early acute lower limb deep vein thrombosis (DVT), providing more clinical evidence for the management of early acute lower limb DVT. The study will follow strict patient selection criteria, including factors such as age, gender, thrombus size, and location, and will detail the specific implementation steps of catheter-directed thrombolysis, including the type, dosage, and duration of thrombolytic drugs. Deep vein thrombosis (DVT) is a serious thrombotic condition, and despite advancements in treatment, uncertainty remains regarding the choice of pathway in catheter-directed thrombolysis (CDT). While current literature offers insights into the efficacy of CDT, direct comparisons between different pathways are scarce. Therefore, this study aims to bridge this gap by directly comparing the efficacy of CDT via popliteal vein and femoral vein pathways, providing clearer guidance for clinical decision-making.

This study aims to fill this gap by directly comparing the effectiveness and safety of CDT via the subpatellar (or infra-knee) vein versus the conventional popliteal vein approach in patients with early acute DVT of the lower extremities. The comparison of these two specific CDT methods is clinically significant as it addresses the need for evidence-based guidance in selecting the optimal catheter insertion route, considering factors such as procedural efficacy, patient comfort, and long-term outcomes. To compare the efficacy and safety of catheter-directed thrombolysis (CDT) via the subpatellar vein versus the popliteal vein in patients with early acute lower limb deep vein thrombosis (DVT), with a focus on surgical parameters, thrombolysis outcomes, vein patency, and adverse reactions.

METHOD

Study design

Patients were categorized into two groups based on the approach used for thrombolysis: Group A received CDT via the subpatellar vein, while Group B underwent CDT through the popliteal vein. Each group comprised 80 early-stage acute lower extremity DVT patients, totaling 160 participants enrolled at our hospital from January 2020 to October 2023. From January 2020 to October 2023, our hospital included early acute lower limb DVT patients who met the following inclusion criteria: 1) Patients diagnosed with DVT based on ultrasound and angiographic examinations, with results indicating the presence of thrombosis and clinical symptoms including lower limb swelling, intense pain, and elevated skin surface temperature, leading to a clear diagnosis of DVT. 2) Patients with unilateral lower limb venous thrombosis. 3) Age greater than 18 years. 4) Patients receiving treatment within one week from the onset of symptoms. 5) Patients in good physical condition and able to tolerate surgical intervention.

Exclusion criteria included: 1) Patients with severe underlying conditions such as uncontrolled hypertension, diabetes, or other comorbidities. 2) Patients with severe hepatic or renal system diseases and significant impairment of liver or kidney function. 3) Patients with severe coagulation abnormalities or abnormal platelet levels 4) Patients unable to complete the entire follow-up period. The envelope method was used to group the patients, with the control group undergoing catheter-directed thrombolysis via the popliteal vein approach and the research group undergoing catheter-directed thrombolysis via the subpatellar vein approach.

All patients received postoperative urokinase treatment. For patients under 60 years of age, urokinase was administered at a rate of 600 000 IU per day, while for patients over 60 years of age, the rate was 400 000 IU per day. Continuous thrombolysis was performed through a thrombolysis catheter. Additionally, patients were prescribed oral rivaroxaban at a dose of 20 mg per day, and every 12 hours, they were given low molecular weight heparin at a dose of 0.1 mL per 10 kg for anticoagulation therapy. Plasma fibrinogen (Fib) levels were monitored daily, and if the Fib concentration dropped below 1.5 g/L, medication doses were reduced. Thrombolysis treatment was discontinued when the Fib concentration dropped below 1.0 g/L.

Patients underwent catheter-directed thrombolysis via the subpatellar vein approach in the research group. Patients were positioned supine and monitored using electrocardiography. A tourniquet was applied around the ankle and knee joints of the affected side to restrict blood reflux in superficial veins. Subsequently, a needle was inserted into the dorsalis pedis vein, and a contrast medium was injected to perform the affected lower limb venography, aiming to assess the thrombus condition in the lower limb veins. The groin area on both sides and the affected lower leg was then disinfected and covered with sterile drapes. Local anesthesia was administered, and under the guidance of ultrasound equipment (model: APLO 500, manufacturer: Toshiba, Japan), the contralateral femoral vein was punctured, and a vascular sheath was inserted. Venography through the sheath confirmed the patency of the inferior vena cava. Subsequently, a longer sheath was placed, and an inferior vena cava filter was placed approximately 0.5 cm to 1 cm below the entrance of the renal vein into the inferior vena cava. After local anesthesia, a 5F vascular sheath was inserted into the knee region of the affected limb (12 cases in the anterior tibial vein, 68 cases in the posterior tibial vein), and a single-curved guidewire was inserted through this sheath to perform segmental venography of the lower limb veins, accurately determining the location and extent of the thrombus. Depending on the size of the thrombus, a thrombolysis catheter with a length of 30 cm to 50 cm was inserted into the lower limb veins.

Procedure Descriptions: Both CDT procedures were performed under local anesthesia. In the subpatellar vein approach, a small incision was made below the knee, and the catheter was advanced under ultrasound guidance. Thrombolytic agent infusion was then initiated directly into the clot. Similarly, in the popliteal vein approach, a small incision was made behind the knee, and the catheter was advanced under ultrasound guidance to the target site for thrombolysis.

Patients will be assigned to different treatment groups based on strict criteria, and relevant information will be documented. Pre-treatment imaging assessments will guide the allocation of thrombolytic drugs. Regular clinical evaluations and imaging checks will be conducted throughout the treatment process. The efficacy and safety of different treatment pathways will be assessed through descriptive statistics and comparative analysis. These methods will ensure that the research outcomes directly and logically address the research question, providing reliable guidance for clinical practice. In the control group, patients underwent catheter-directed thrombolysis via the popliteal vein approach. The surgical procedure for placing the inferior vena cava filter was the same as that of the research group. Subsequently, patients assumed a prone position, and under ultrasound guidance, the popliteal vein was punctured, with the subsequent procedures matching those of the research group.

A lower limb venography examination was conducted on the day after the operation to observe the clearance status of the thrombus. Once the thrombus was cleared, if iliac vein compression was detected, balloon dilation or stent implantation was performed through the sheath. Additionally, the inferior vena cava filter was removed if conditions allowed and based on the patient's specific situation.

Postoperative Care and Monitoring: Following the procedure, patients were monitored closely for any signs of bleeding, allergic reactions, or other complications. Daily Doppler ultrasound assessments were performed to monitor thrombus resolution and vein patency. Patients were also instructed to report any symptoms such as pain, swelling, or changes in limb color or temperature promptly.

Surgical indicators for both patient groups were recorded, including hospital stay, thrombolysis time, total urokinase dose, and X-ray exposure time. A circumference measuring tape documented thigh circumference differences between the affected and healthy limbs before and after thrombolysis. The reduction rate was calculated as the ratio of the post-thrombolysis circumference difference to the pre-thrombolysis circumference difference, expressed as a percentage. Venous whole blood samples (5 mL) were collected from patients before and after thrombolysis. These samples were analyzed using the Sysmex CS-5100 coagulation analyzer to measure various coagulation parameters, including Prothrombin Time (PT), International Normalized Ratio (INR), Activated Partial Thromboplastin Time (APTT), Fibrinogen (FIB), Thrombin Time (TT), and D-dimer (D-D). All patients underwent digital subtraction angiography to assess lower limb vein patency before and after thrombolysis. The evaluation was conducted using the Porter scoring system,[7] with scores assigned as follows: 0 for complete vein patency, 1 for partial patency, and 2 for vein occlusion. Cumulative scores were assigned to the inferior vena cava, segments of the femoral vein, common femoral vein, common iliac vein, popliteal vein, and external iliac vein, resulting in a total score of 14. The patency rate was calculated as the percentage change in scores before and after thrombolysis compared to the pre-thrombolysis score. Postoperative comfort was assessed using the Comfort Scale (GCQ), which comprises 28 items rated on a scale from 1 to 4. Scores ranged from 28 to 112, with higher scores indicating greater comfort. Comfort levels were recorded three days after surgery, and the mean score was calculated to measure postoperative comfort. In both patient groups, the incidence of complications, such as hematoma at the puncture site, hematuria, melena, bleeding from the skin or mucous membranes, infections, and superficial vein varicosities, was documented, and the overall complication rate was calculated.

Statistical analysis

Data analysis will be conducted using SPSS version 26. Continuous variables will be presented as means ± standard deviations and compared using independent *t* tests or Mann-Whitney U tests, depending on the distribution. Categorical variables will be presented as frequencies and compared using chi-square tests or Fisher's exact tests, as appropriate. Statistical significance will be set at $P < .05$.

RESULTS

Recapping the study design, we initially considered 176 patients for inclusion in the study. Of these, 160 patients met the eligibility criteria and were included in the analysis. The 16 excluded patients were primarily due to contraindications to thrombolysis or failure to provide informed consent. The specific process can be seen in Figure 1. Within the groups, the control group consisted of 80 patients who underwent

Figure 1. Patient Enrollment Flowchart

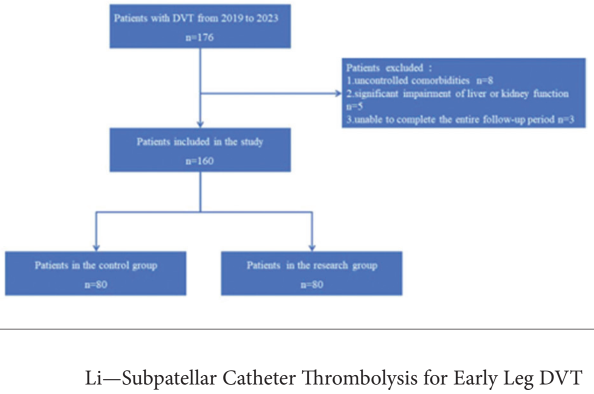

Table 1. Comparison of General Demographic Data between the Two Groups [±s, n/(%)]

Group	Sex		BMI (kg/m²)	Smoking history		Age (Years)	Alcohol consumption history	
	Male	Female		Yes	No		Yes	No
Control (n=80)	34(42.5)	46(57.5)	22.16±2.12	30(37.5)	50(62.5)	64.15±11.26	45(56.2)	35(43.8)
Research (n=80)	29(36.25	51(63.75	22.45±2.16	36(45.0)	44(55.0)	61.58±12.30	39(48.8)	41(51.2)
χ^2/t	0.655		-0.909	0.828		1.379	0.902	
P value	.419		.365	.335		.170	.342	
Group	Etiology					Disease course(d)	Side	
	Postoperative	Post-fracture surgery	Post-obstetric surgery	Stroke	Other		Left	Right
Control(n=80)	22(27.5)	26(32.5)	13(16.2)	6(7.5)	13(16.2)	2.17±0.98	63(78.8)	17(21.2)
Research(n=80)	20(25.0)	24(30.0)	14(17.5)	8(10.0)	14(17.5)	2.26±0.76	65(81.2)	15(18.8)
χ^2/t	0.535					0.716	0.156	
P value	.970					0.423	0.693	

Table 2. Comparison of Surgical Indicators between the Two Groups ($\bar{x} \pm s$)

Group	Operative time (min)	Thrombolysis time(d)	Total urokinase dosage (ten thousand IU)	X-ray exposure time (min)
Control (n=80)	49.00±7.20	5.00±1.30	256.00±87.10	17.00±2.10
Research (n=80)	64.00±5.80	5.00±1.00	145.00±63.60	22.00±2.20
t	-15.03	0.000	9.503	-15.11
P value	.000	>.999	.000	.000

Table 3. Comparison of Thigh Circumference Differences and Edema Reduction Rates between the Two Groups of Patients Before and After Thrombolysis ($\bar{x} \pm s$)

Group	Thigh Circumference difference between the affected and healthy sides (cm)		Edema reduction rate(%)	Calf circumference difference between the affected and healthy sides (cm)		Edema reduction rate(%)
	Prior to thrombolysis	After thrombolysis		Prior to thrombolysis	After thrombolysis	
Control (n=80)	4.98±2.12	1.78±0.45[a]	64.26±12.56	3.65±1.12	1.48±0.51[a]	59.45±8.49
Research (n=80)	4.56±1.89	1.65±0.51[a]	66.89±11.05	3.48±1.55	1.12±0.44[a]	67.82±7.15
t	1.403	1.813	-1.491	0.843	5.070	-7.154
P value	.162	.071	.138	.400	.000	.000

[a]$P < .05$ indicates a statistically significant difference when compared to the same group before thrombolysis.

Table 4. Serum Parameter Analysis Before and After Thrombolysis in Two Groups of Patients (±s)

Group	TT(s)		PT(s)		APTT(s)	
	Prior to thrombolysis	After thrombolysis	Prior to thrombolysis	After thrombolysis	Prior to thrombolysis	After thrombolysis
Control (n=80)	10.65±0.56	15.31±1.23[a]	10.36±0.89	12.45±0.64[a]	23.45±2.31	33.45±3.15[a]
Research (n=80)	10.66±0.48	15.58±1.12[a]	10.33±0.78	12.98±0.77[a]	23.77±1.98	33.98±1.26[a]
t	-0.129	-1.540	0.240	-1.895	-0.998	-1.482
P value	0.898	0.125	0.810	0.060	0.320	0.140
Group	FIB(g/L)		D-D(mg/L)		INR	
	Prior to thrombolysis	After thrombolysis	Prior to thrombolysis	After thrombolysis	Prior to thrombolysis	After thrombolysis
Control (n=80)	3.99±0.78	3.66±0.62[a]	0.67±0.15	0.51±0.11[a]	0.98±0.13	1.35±0.12[a]
Research (n=80)	4.02±0.67	3.55±0.61[a]	0.72±0.13	0.48±0.13[a]	0.95±0.15	1.39±0.23[a]
t	-0.277	1.200	-2.390	1.671	1.434	-1.463
P value	0.782	0.232	0.018	0.096	0.153	0.145

[a]$P < .05$ indicates a statistically significant difference when compared to the same group before thrombolysis.

Table 5. Comparison of Lower Limb Vein Patency and Comfort Before and After Thrombolysis in Two Groups of Patients ($\bar{x} \pm s$)

Group	Porter score		Vein patency rate (%)	GCQ score
	Prior to thrombolysis	After thrombolysis		
Control (n=80)	8.79±1.12	4.41±1.31[a]	48.56±12.02	68.23±8.23
Research (n=80)	8.77±1.31	3.41±1.25*	61.11±11.12	75.56±7.64
t	0.050	5.239	-7.271	-6.192
P valuev	.961	.000	.000	.000

[a]$P < .05$ indicates a statistically significant difference when compared to the same group before thrombolysis.

catheter-directed thrombolysis via the popliteal vein approach, while the research group comprised 80 patients who underwent catheter-directed thrombolysis via the subpatellar vein approach. The general demographic data for both groups are summarized in Table 1, and there were no statistically significant differences in the general demographic data between the two groups ($P > .05$). Table 1 presents the baseline characteristics of the study population, including demographic information and baseline thrombus characteristics. Figure 1 illustrates the total urokinase dosage administered in each group over the treatment period.

In the comparative analysis of surgical indicators between the two groups, it was observed that in comparison to the control group, patients in the research group exhibited an increase in surgical duration and X-ray exposure time, whereas there was a significant reduction in the total urokinase dosage administered ($P < .05$). However, the two groups had no statistically significant difference in thrombolysis time ($P > .05$). Detailed data can be found in Table 2.

In the comparative analysis of thigh circumference differences and edema reduction rates between the two groups of patients before and after thrombolysis, there were no significant differences in thigh circumference differences or edema reduction rates between the two groups before thrombolysis ($P > .05$). Additionally, there were no significant differences in calf circumference differences between patients before thrombolysis ($P > .05$). However, after thrombolysis, patients in the research group exhibited lower calf circumference differences and higher edema reduction rates compared to the control group ($P < .05$). Specific details can be found in Table 3.

In the serum parameter analysis of the two groups of patients before and after thrombolysis, it was observed that there were no statistically significant differences in PT, INR, APTT, FIB, TT, and D-D levels between the control group and the research group before and after thrombolysis ($P > .05$). Post-thrombolysis, both groups exhibited an increase in PT, INR, APTT, and TT levels and a decrease in FIB and D-D levels compared to pre-thrombolysis values ($P < .05$). Specific data can be found in Table 4.

In the comparative analysis of lower limb vein patency and comfort between the two groups of patients before and after thrombolysis, while there were no statistically significant differences in Porter scores between the two groups before thrombolysis ($P > .05$), it is noteworthy that after thrombolysis, both groups exhibited a decrease in Porter scores, with the research group showing a greater reduction ($P < .05$). Additionally, patients in the research group had higher vein patency rates and GCQ scores compared to the control group ($P < .05$). Specific details can be found in Table 5.

In comparing the incidence of complications between the two groups of patients, there were no statistically significant differences in the occurrence of adverse reactions between the control group and the research group ($P > .05$). Unexpectedly, there were no significant differences in the incidence of post-thrombolysis complications between the study and control groups. This contrasts with previous literature suggesting a higher risk of complications with catheter-directed thrombolysis. Further exploration of this finding is warranted to understand potential contributing factors. Specific details can be found in Table 6.

Table 6. Comparison of Incidence of Complications in Two Groups of Patients (n/%)

Group	Puncture hematoma	Hematuria	Bloody stools	Skin and mucous membrane bleeding	Infection	Overall incidence of complications
Control (n=80)	3(3.75)	2(2.5)	1(1.25)	1(1.25)	2(2.5)	9(11.2)
Research (n=80)	2(2.5)	1(1.25)	0(0.00)	0(0.00)	1(1.25)	4(5.0)
χ^2						2.093
P value						.148

DISCUSSION

To provide a contextual framework for our discussion, let's summarize the main findings of our study. Our investigation compared the efficacy and safety of intravenous thrombolysis via the subpatellar vein versus the popliteal vein in early acute deep venous thrombosis (DVT) of the lower extremities. Notably, we observed significant differences in thrombolysis outcomes and postoperative complications between the two approaches. In traditional treatment approaches, the management of DVT primarily relies on systemic anticoagulation therapy, with the core objective of preventing further thrombus extension and reducing the risk of Post-thrombotic Syndrome (PTS).[8] However, for mixed or proximal thrombi in the iliac-femoral region, there is a possibility of causing persistent venous functional impairment or triggering PTS symptoms. Studies have shown that using Catheter-Directed Thrombolysis (CDT) to treat acute lower limb DVT can deliver higher concentrations of thrombolytic agents directly to the thrombus site, thereby reducing the required thrombolysis time.[9] Furthermore, this approach helps protect the deep venous valves and lowers the risk of swelling and fibrous dissolution, thus enhancing treatment efficacy.[10] Nowadays, most treatment centers tend to choose the popliteal vein as the access route for catheter placement. However, this access method requires strict patient positioning, often necessitating the patient to lie prone or on their side. Such maneuvers can lead to damage to surrounding tissues. Additionally, during the entire thrombolysis procedure, patients must keep their knee joint extended, as any bending may result in bleeding at the puncture site and restrict the sheath, complicating postoperative care.[5,11] Therefore, in this study, we attempted ultrasound-guided puncture of the infra-popliteal vein for thrombolysis to optimize treatment outcomes and enhance patient comfort.

The results of this study showed that both groups had a similar thrombolysis time with no significant differences. However, the surgical time and X-ray exposure time increased in the research group. At the same time, the total dose of urokinase decreased compared to the control group, and the post-thrombolysis leg circumference difference in the research group was lower, with a higher rate of edema reduction ($P < .05$). This suggests that compared to the popliteal vein approach, the infra-popliteal vein approach may have slightly longer surgical and X-ray exposure times but offers better edema reduction in the lower leg. Furthermore, the study results revealed that after thrombolysis, both groups had increased levels of PT, INR, APTT, TT. In contrast, FIB and D-D levels decreased compared to pre-thrombolysis levels ($P < .05$), which may be related to the thrombolytic treatment. Moreover, after thrombolysis, both groups showed lower Porter scores than pre-thrombolysis scores, with the research group exhibiting a greater reduction ($P < .05$). Additionally, patients in the research group had higher vein patency rates and GCQ scores than the control group ($P < .05$). This indicates that despite similar trends in serum markers in both groups, the infra-popliteal vein approach resulted in better vein patency and higher comfort levels based on the Porter score. This is because the infra-popliteal vein has a smaller diameter, requiring more precise puncture during surgery. Moreover, it is situated deeper and is surrounded by muscles and other tissues, making direct visual localization more challenging.[12] These factors together contribute to increased X-ray exposure and extended surgical time during the procedure. In contrast, the popliteal vein has a larger diameter and is more superficial, making the surgical procedure more straightforward. Another reason for the lower urokinase dosage in the research group may be that the infra-popliteal vein has numerous fine branches. When the thrombolytic drug is delivered through the catheter, it can be distributed more evenly among these small branches, ensuring drug coverage over a larger affected area and achieving the fastest and most comprehensive dissolution effect.[3,13] Additionally, the infra-popliteal or posterior tibial vein puncture access involves "antegrade interventional procedures," which entails direct contact of the skin with the anterior or posterior tibial veins, and the catheter is advanced along the direction of valve flow in the vein, following the normal direction of blood flow. This approach helps maintain the integrity of venous valves, preventing issues like blood stasis and venous hypertension.[14] The infra-popliteal vein access ensures healthy venous valve function and normal blood flow, making it particularly effective for treating lower leg swelling. Regarding patient comfort, the popliteal vein approach requires frequent changes in position, which may be challenging for elderly, high-risk, or fracture patients. Additionally, postoperatively, patients need to maintain immobility for an extended period, which can be challenging for patients to comply with and may lead to difficult-to-manage sheath bleeding if joint movement occurs. In contrast, the infra-popliteal vein approach avoids these issues.

In this study, the authors observed that among patients who underwent the infra-popliteal vein approach, most (68 cases) chose the posterior tibial vein as the access route, while fewer patients (12 cases) chose the anterior tibial vein. This may indicate that the posterior tibial vein is anatomically easier to puncture and operate on or may be the primary site of thrombus formation. This choice may be because the posterior tibial vein is located on the inner side of the lower leg, making it easy to expose in the patient's natural position.[15] In contrast, the anterior tibial vein is deeper in the lower leg, surrounded by thick muscles, and may not have clear ultrasound images, making puncture more difficult. Furthermore, the fibular vein is usually smaller than the other two veins and is less visible under ultrasound, resulting in lower visibility.[16] Based on the experience of this center and previous literature reports,[17,18] the authors summarized the experience of ultrasound-guided puncture of the infra-popliteal vein as follows: In cases where the iliac vein remains narrowed after thrombolysis, the choice of a larger diameter balloon for dilation treatment should be made based on the diameter of the narrow section's upstream and downstream vessels. Suppose the narrowed portion remains above 50% after balloon dilation, and there is no significant reduction in collateral blood flow around the pelvic floor. In that case, it is recommended that stent implantation surgery be proceeded with. Limitations of the study include potential constraints on sample size, methodological biases, and the single-center design, which may limit the external validity of the results. Additionally, the limitations of current technology and treatment methods could affect the applicability of the findings. This study addresses the lack of direct comparisons between popliteal vein and femoral vein pathways in catheter-directed thrombolysis (CDT) for deep vein thrombosis (DVT).

Practical Considerations

Our findings have significant implications for clinical practice. Incorporating the infra-popliteal approach into thrombolysis protocols for early acute DVT could potentially improve patient outcomes, including higher rates of thrombus resolution and reduced incidence of post-thrombolysis complications. Clinicians should consider adopting this approach as a standard of care, especially in cases where conventional methods yield suboptimal results.

Limitations

Despite the insights provided by our study, several limitations must be acknowledged. The single-center design may limit the generalizability of our findings to broader patient populations. Additionally, potential biases inherent in retrospective data collection and analysis should be considered when interpreting the results. Future research endeavors should aim to address these limitations through larger-scale multicenter trials and prospective study designs.

Future Research Directions

Moving forward, future research should focus on addressing the limitations of our study and further exploring the efficacy and safety of the infra-popliteal approach in DVT management. Large-scale multicenter trials are warranted to validate our findings across diverse patient populations. Additionally, investigating the long-term outcomes and comparative effectiveness of different thrombolytic agents administered via the infra-popliteal route can provide valuable insights for optimizing treatment strategies in clinical practice.

CONFLICT OF INTEREST

The authors have no potential conflicts of interest to report relevant to this article.

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AUTHOR CONTRIBUTIONS

JL and HG designed the study and performed the experiments, HG and ML collected the data, WG and YC analyzed the data, JL prepared the manuscript. All authors read and approved the final manuscript.

ETHICAL COMPLIANCE

The ethics committee of Taihe Hospital of Traditional Chinese Medicine, Affiliated to Anhui University of Chinese Medicine approved this study. Signed written informed consent were obtained from the patients and/or guardians.

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