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Original Article

Syringe-assisted aspiration combined with mechanical aspiration thrombectomy effectively alleviates lower extremity deep vein thrombosis

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Abstract: Objective: To evaluate the safety and efficacy of syringe-assisted aspiration combined with mechanical aspiration thrombectomy in the management of lower-extremity deep vein thrombosis (DVT). Methods: A retrospective analysis was conducted on 112 patients with DVT admitted to our hospital between January 2024 and June 2025. Patients were allocated to either the Mechanical Aspiration group (MA group, n = 50) or the Syringe-Assisted Mechanical Aspiration group (SMA group, n = 62). Outcomes compared between the two groups included stent implantation rate, thrombolysis duration and thrombolytic drug dosage, limb swelling rate, thrombus clearance rate, lower-limb circumference difference, venous patency score, Villalta scale for post-thrombotic syndrome, hemodynamic parameters, quality of life, complications, and recurrence. Results: Baseline characteristics were comparable between the two groups. The SMA group demonstrated a lower stent implantation rate, shorter thrombolysis duration, higher limb deswelling and thrombus clearance rates, and lower urokinase dosage, hospitalization time, and medical costs ($P < 0.05$). All clinical indicators improved after treatment, with greater improvements observed in the SMA group. No significant differences were found in complication or recurrence rates between the groups ($P > 0.05$). Conclusion: Syringe-assisted aspiration combined with mechanical aspiration thrombectomy is an effective and safe treatment option for lower-extremity DVT. This combined approach can reduce thrombolytic drug requirements and hospitalization costs, enhance hemodynamics and quality of life, and demonstrate a favorable safety profile.

Keywords: Syringe-assisted aspiration, mechanical thrombectomy, thrombectomy, lower extremity deep vein thrombosis, safety

Introduction

Lower extremity deep vein thrombosis (DVT) is a vascular occlusive disorder caused by abnormal coagulation within the deep venous system. It most commonly involves the calf intramuscular veins and the iliofemoral venous segment. Clinical manifestations of DVT range from mild symptoms - such as limb swelling, pain, and increased skin temperature - to complications, including pulmonary embolism resulting from thrombus detachment, which can be life-threatening [1]. With disease progression, some patients may develop post-thrombotic syndrome, characterized by chronic pain, skin hyperpigmentation, and, in advanced cases, venous ulceration, all of which severely affect quality of life. Current treatment strategies for DVT primarily include anticoagulation, thrombolytic therapy, and mechanical intervention [2]. Anticoagulation remains the cornerstone of therapy and effectively prevents thrombus extension and recurrence; however, it has a limited ability to dissolve pre-existing thrombi [3]. Systemic thrombolysis can promote thrombus dissolution but is constrained by a high risk of bleeding [4]. The challenge of achieving rapid and effective thrombus removal while minimizing bleeding and overall treatment burden, remains a critical concern in DVT management. In recent years, advances in interventional techniques have led to the increasing use of mechanical thrombectomy in clinical practice. This approach enables prompt thrombus deb-

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ulking, restoration of venous blood flow, reduction of venous pressure, relief of acute symptoms, and preservation of valvular function [5, 6]. Nevertheless, when performed alone, mechanical thrombectomy may not always achieve complete thrombus clearance; adjunctive thrombolytic agents are often required, increasing procedural complexity and bleeding risk. Thus, there is a pressing need for new therapeutic strategies that achieve high thrombus clearance while reducing reliance on thrombolytics and maintaining a favorable safety profile - addressing the limitations inherent to mechanical thrombectomy used as a single modality.

Syringe-assisted aspiration has emerged in recent years as a supplementary technique for thrombus removal and has been increasingly applied in clinical practice [7]. By generating controlled negative pressure through a syringe, this technique enables targeted aspiration and preliminary clearance of thrombi. It offers advantages, such as procedural simplicity, high thrombus removal efficiency, and a low risk of perioperative complications [8]. Notably, syringe-assisted aspiration provides stable and adjustable negative pressure, which may enhance thrombus stripping efficiency without increasing device complexity, thereby demonstrating strong potential for broader clinical application. In patients with acute lower extremity DVT, this method can rapidly relieve venous obstruction and reduce the incidence of severe complications such as pulmonary embolism. However, limited evidence exists regarding whether combining syringe-assisted aspiration with conventional mechanical aspiration can further optimize therapeutic efficacy and safety. Unlike previous studies that primarily focused on single-device strategies or traditional mechanical suction, the present study explores the synergistic potential of integrating syringe-assisted and mechanical aspiration techniques. Specifically, we aimed to investigate whether this combined approach could enhance thrombus clearance efficiency, reduce thrombolytic drug requirements, and potentially lower bleeding risk, with the aim of providing a reference for improving therapeutic strategies for DVT. The findings are summarized as follows.

Materials and methods

General data

A retrospective analysis was conducted on 112 patients with DVT who were admitted to our hospital between January 2024 and June 2025. Patients were divided into two groups according to the treatment strategies modality received: the Mechanical Aspiration group (MA group, n = 50), which underwent mechanical thrombectomy alone, and the Syringe-Assisted Mechanical Aspiration group (SMA group, n = 62), which received syringe-assisted aspiration combined with mechanical thrombectomy. Inclusion criteria were as follows: (1) diagnosis of DVT in accordance with established criteria and confirmed by imaging [9]; (2) system duration ≤ 30 days; (3) age between 18 and 70 years; and (4) complete clinical data. Exclusion criteria included: (1) bilateral lower limb involvement; (2) poor treatment compliance; (3) pregnancy or lactation; (4) severe hepatic or renal dysfunction; (5) coexisting malignancy; (6) allergy to anticoagulant or thrombolytic agents; or (7) active bleeding within the 4 weeks prior to enrollment. This study was approved by the institutional ethics committee and conducted in accordance with the principles of the Declaration of Helsinki. As this was a retrospective study involving no additional interventions, so the requirement for informed consent was waived by the Lanxi City People's Hospital's committee. Patient privacy was strictly protected throughout the study; all data were anonymized and contained no identifiable personal information.

Methods

Patients in the MA group underwent mechanical thrombectomy. Preoperative evaluation included comprehensive lower-extremity venography and Doppler ultrasonography to determine the extent and location of the thrombus. For patients considered at high risk for pulmonary embolism, an inferior vena cava filter was placed prior to the procedure for protection. All procedures were performed under local anesthesia. The affected femoral or popliteal vein was selected as the access site, and percutaneous vascular access was established. An aspiration catheter was then advanced to the thrombus site, after which negative pressure

aspiration was initiated to remove thrombotic material. Mechanical manipulation of the catheter was used to fragment the thrombus and enhance aspiration efficiency. When necessary, local administration of thrombolytic agents was provided intraoperatively to facilitate the clearance of residual thrombi. Upon completion of thrombectomy, angiography was performed to evaluate thrombus clearance and vascular recanalization. After the procedure, standard anticoagulation therapy was initiated to prevent thrombus recurrence, supplemented by supportive measures as clinically indicated.

Patients in the SMA group underwent syringe-assisted aspiration combined with mechanical thrombectomy. Preoperative preparation was identical to that of the MA group. All procedures were performed under local anesthesia. The contralateral femoral vein was punctured, and a 5F vascular sheath was inserted. A PIG angiographic catheter was advanced to perform inferior vena cava venography to assess thrombus burden and distribution. When indicated, a retrievable filter was deployed below the level of the renal veins for embolic protection. The aspiration catheter was then navigated to the target thrombus. Urokinase solution (400,000 units diluted in 100 mL of normal saline) was delivered in a jet injection mode through the catheter, with infusion directed from the popliteal vein toward the iliac vein for 15 minutes. The system was then switched to aspiration mode, and negative pressure aspiration was performed along the same trajectory. A 50 mL syringe was connected to the catheter to provide manual, repeated aspiration, thereby improving thrombus clearance efficiency. Repeat angiography was conducted to evaluate residual thrombus. If substantial thrombus remained, additional aspiration cycles were performed, with the cumulative aspiration duration maintained within 8 hours. Postoperative management followed the same protocol as in the MA group.

Observation indicators

To comprehensively assess the efficacy and safety of the two treatment modalities, the observation indicators in this study were categorized into primary and secondary outcomes. Primary outcomes were selected to directly reflect thrombus clearance and short-term therapeutic efficacy, including stent implantation, average thrombolysis duration, thrombus clearance rate, and limb deswelling rate.

Stent implantation: The number of patients in each group requiring stent implantation due to residual stenosis or elastic recoil during the procedure was recorded. The stent implantation rate was calculated, and the diameter (mm) and length (mm) of the implanted stents were documented.

Thrombolysis and limb detumescence: The mean thrombolysis time, limb detumescence rate, and thrombus clearance rate were compared between the two groups. Mean thrombolysis time: defined as the interval from the initiation of thrombolytic therapy to the confirmation of vascular recanalization on postoperative angiography, with restored blood flow of TIMI grade $\geq$ 2. Thrombus clearance rate: assessed immediately after the procedure using digital subtraction angiography (DSA). Successful recanalization was defined as $\geq$ 90% thrombus removal, and the percentage of such cases was calculated. Limb detumescence rate: defined as complete or near-complete resolution of swelling - indicated by a difference in circumference of < 1 cm between the affected and contralateral limbs, accompanied by normalization of skin tension. The detumescence rate was calculated as the proportion of patients achieving this outcome.

Secondary observation indicators included thrombolytic drug dosage, length of hospitalization, peripheral circumference difference in the lower limbs, venous patency score, hemodynamic parameters, Villalta score, complications and recurrence, and quality of life. These measures were used to comprehensively evaluate patient recovery and the stability of therapeutic outcomes.

Thrombolytic drug dosage and hospitalization parameters: For each patient, the total intraoperative dosage of urokinase (10,000 units), total length of hospital stay (days) from admission to discharge, and overall hospitalization cost (10,000 yuan) were recorded.

Lower limb circumference difference: Lower-limb circumference measurements were per-

formed by the same experienced physician before treatment and at 3 months post-treatment using a standard flexible measuring tape. The calf was measured 10 cm below the tibial tuberosity, and the thigh was measured 15 cm above the superior border of the patella. The circumference difference between the affected limb and the contralateral healthy limb was calculated.

Venous patency score: Venous patency was evaluated before treatment and at 3 months after treatment using color Doppler ultrasonography performed by the same team of experienced sonographers. The scoring criteria were as follows: 0 points for complete patency, 1 point for partial patency (partial restoration of flow signals), and 2 points for complete occlusion (absence of flow signals).

Hemodynamic parameters: Before treatment and 3 months after treatment, color Doppler ultrasonography was performed to assess hemodynamic parameters of the affected midfemoral vein, including mean blood flow velocity and blood flow volume. All examinations were conducted by the same experienced sonography team to ensure consistency.

Villalta score: The severity of DVT in both groups was assessed before treatment and at 3 months after treatment using the Villalta scoring system. This scale includes five symptoms (pain, cramps, heaviness, paresthesia, and pruritus) and six signs (pretibial edema, skin induration, hyperpigmentation, redness, venous ectasia, and tender induration). Each item is scored from 0 to 3 according to severity, with the total symptom score ranging from 0 to 15 and the total sign score from 0 to 18. Higher scores indicate greater severity of DVT.

Complications and recurrence: All patients were followed for 3 months, and the occurrence of complications was recorded, including puncture site bleeding, urinary tract bleeding, and gastrointestinal bleeding. Thrombus recurrence was determined by the presence of new thrombus formation in the ipsilateral deep venous system, as detected by ultrasonography during follow-up. The incidence of individual complications and the overall recurrence rate were calculated.

Quality of life: Quality of life was assessed in both groups before treatment and at 3 months post-treatment using the Generic Quality of Life Inventory-74 (GQOLI-74). This questionnaire includes four dimensions: physical function, psychological function, material life status, and social function, each with a maximum score of 100 points. Higher scores indicate a better quality of life. The questionnaire was self-administered by patients and collected on-site upon completion.

Statistical analysis

Data were analyzed using SPSS version 25.0. Measurement data were expressed as mean ± standard deviation (x ± s) and compared between groups using independent samples t-tests; within-group comparisons were performed using paired t-tests. Categorical data were presented as percentages and analyzed using the χ^2 test. A P value < 0.05 was considered statistically significant.

Results

Clinical data

There were no significant differences between the two groups in terms of sex, body mass index (BMI), age, affected limb, DVT type (central/mixed), or comorbidities (P > 0.05). Baseline characteristics were well balanced and comparable between groups (**Table 1**).

Stent implantation

The stent implantation rate in the SMA group (syringe-assisted aspiration combined with mechanical thrombectomy) was 40.32% (25/62), which was significantly lower than that in the MA group (mechanical thrombectomy alone), 60.00% (30/50) (P < 0.05, **Figure 1A**). In addition, the mean stent diameter in the MA group (12.95 ± 0.43 mm) was significantly larger than that in the SMA group (12.71 ± 0.54 mm; t = -2.58, P = 0.011). While the visual differences in stent placement between groups are subtle (**Figure 1B**, **1C**), quantitative analysis indicates that the SMA group demonstrates advantages in stent-related parameters. These results suggest that combined therapy may achieve more efficient thrombus clearance, thereby reducing the need for stent implantation due to residual stenosis or elastic recoil (**Figure 1**).

Thrombolysis and limb detumescence

The mean thrombolysis time in the SMA group was significantly shorter than that in the MA group (3.37 ± 0.45 days vs. 4.98 ± 0.56 days,

Table 1. Comparison of baseline characteristics between the two groups

Clinical data	MA group (n = 50)	SMA group (n = 62)	χ^2/t	*P*
Gender			0.826	0.363
Male	34 (68.00)	37 (59.68)		
Female	16 (32.00)	25 (40.32)		
Age (years, $\bar{x} \pm s$)	53.68 ± 5.37	54.05 ± 5.45	0.360	0.720
Body mass index (kg/m^2, $\bar{x} \pm s$)	22.81 ± 2.31	22.95 ± 2.17	0.330	0.742
Affected limb			0.063	0.801
Left	27 (54.00)	32 (51.61)		
Right	23 (46.00)	30 (48.39)		
DVT type			0.015	0.902
Central type	22 (44.00)	28 (45.16)		
Hybrid type	28 (56.00)	34 (54.84)		
Disease course (days, $\bar{x} \pm s$)	6.56 ± 1.84	6.27 ± 1.75	0.852	0.396
Comorbidities				
Hypertension	7 (14.00)	8 (12.90)	0.029	0.866
Diabetes	4 (8.00)	5 (8.06)	0.114	0.736
Coronary heart disease	3 (6.00)	3 (4.84)	0.023	0.880

Note: DVT, deep vein thrombosis; MA group, Mechanical Aspiration group; SMA group, Syringe-Assisted Mechanical Aspiration group.

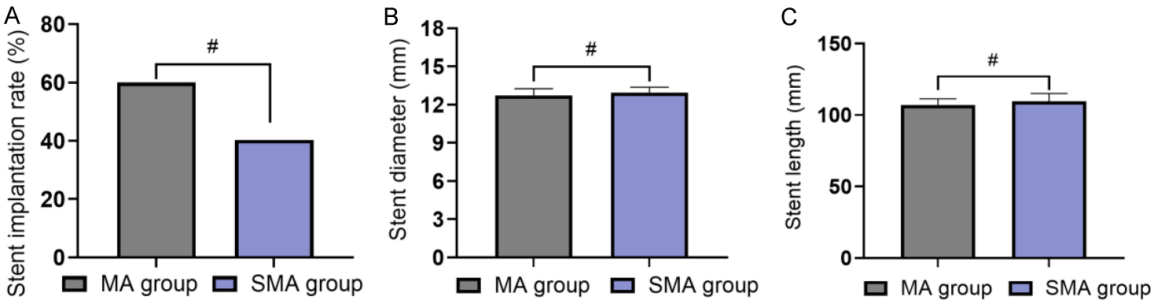

Figure 1. Comparison of stent implantation between the two groups [n (%)]. A. Stent implantation rate (%); B. Stent diameter (mm); C. Stent length (mm). Compared with the MA group, #P < 0.05. MA group, Mechanical Aspiration group; SMA group, Syringe-Assisted Mechanical Aspiration group.

P < 0.05). Additionally, the limb detumescence rate (70.97%) and thrombus clearance rate (88.71%) in the SMA group were higher than those in the MA group (46.00% and 64.00%, respectively), with statistically significant differences (P < 0.05). These results indicate that syringe-assisted aspiration combined with mechanical thrombectomy facilitates faster vascular recanalization and more efficient thrombus removal, thereby promoting more rapid resolution of limb swelling (**Table 2**).

Thrombolytic drug dosage and hospitalization

The total urokinase dosage in the SMA group was significantly lower than that in the MA group (P < 0.05). In addition, both the length of hospital stay and total hospitalization costs were significantly reduced in the SMA group compared with the MA group (P < 0.05). These findings indicate that the combined treatment regimen can achieve effective thrombus clearance while reducing thrombolytic drug use, lowering medical costs, and facilitating faster patient recovery (**Table 3**).

Lower limb circumference difference and venous patency score

Before treatment, no significant differences were observed between the MA and SMA groups regarding lower limb circumference dif-

Table 2. Comparison of thrombolysis duration and limb swelling reduction between the two groups [($\bar{x}$ ± s)/n (%)]

Group	Average thrombolysis time (d)	Limb swelling reduction rate, n (%)	Thrombus clearance rate, n (%)
MA group (n = 50)	4.98 ± 0.56	23 (46.00)	32 (64.00)
SMA group (n = 62)	3.37 ± 0.45	44 (70.97)	55 (88.71)
t/χ^2	16.874	7.179	9.747
P	0.000	0.007	0.002

Note: MA group, Mechanical Aspiration group; SMA group, Syringe-Assisted Mechanical Aspiration group.

Table 3. Comparison of thrombolytic drug dosage and hospitalization parameters between the two groups ($\bar{x}$ ± s)

Group	Urokinase dose (10,000 U)	Length of hospital stay (d)	Hospitalization expenses (10,000 yuan)
MA group (n = 50)	84.26 ± 7.55	10.12 ± 1.55	11.15 ± 1.03
SMA group (n = 62)	77.12 ± 6.90	8.50 ± 1.25	8.40 ± 0.87
t	5.220	6.124	15.316
P	0.000	0.000	0.000

Note: MA group, Mechanical Aspiration group; SMA group, Syringe-Assisted Mechanical Aspiration group.

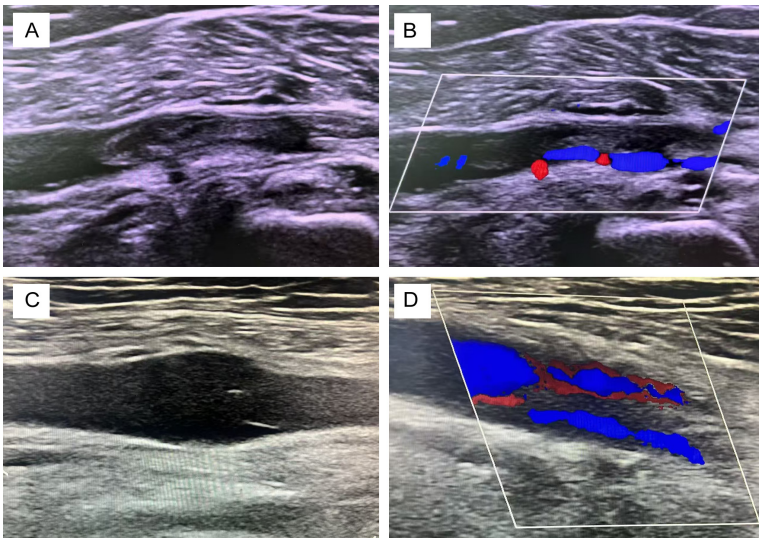

Figure 2. Comparison of ultrasound images before and after treatment in different groups. Ultrasound images of patients in the MA group before treatment (A) and 3 months after treatment (B). Post-treatment images show reduced thrombus burden and improved venous lumen patency. Ultrasound images of patients in the SMA group before treatment (C) and 3 months after treatment (D). Post-treatment images demonstrate substantial thrombus resolution, enhanced blood flow signal, and more complete venous recanalization compared with the MA group. MA group, Mechanical Aspiration group; SMA group, Syringe-Assisted Mechanical Aspiration group.

ferences or venous patency scores (P > 0.05). At 3 months after treatment, both groups showed significant improvements compared with baseline (P < 0.05). Moreover, the SMA group demonstrated significantly greater reductions in calf and thigh circumference differences, as well as more pronounced improvements in venous patency scores, compared with the MA group (P < 0.05). These results further support the superior efficacy of syringe-assisted aspiration combined with mechanical thrombectomy in restoring limb morphology and venous patency (**Figure 2**; **Table 4**).

Hemodynamics

Baseline femoral vein hemodynamic parameters did not differ significantly between the two groups (P > 0.05). At 3 months after treatment, both groups showed significant increases in mean blood flow velocity and blood flow volume compared with baseline (P < 0.05). Importantly, the magnitude of improvements in both parameters was significantly greater in the SMA group than in the MA group (P < 0.05). These findings indicate that the combined treatment regimen can markedly enhance lower limb venous hemodynamics (**Figure 3**).

Table 4. Comparison of lower extremity circumference differences and venous patency score between the two groups ($\bar{x} \pm s$)

Group	Lower leg circumference difference (cm)		Thigh circumference difference (cm)		Venous patency score (points)	
	Before treatment	3 months after treatment	Before treatment	3 months after treatment	Before treatment	3 months after treatment
MA group (n = 50)	4.03 ± 0.70	1.87 ± 0.45*	4.85 ± 0.58	2.03 ± 0.45*	6.17 ± 1.10	2.24 ± 0.55*
SMA group (n = 62)	4.11 ± 0.65	1.52 ± 0.47*	4.91 ± 0.62	1.81 ± 0.39*	6.26 ± 1.25	1.57 ± 0.42*
t	0.626	3.993	0.524	2.770	0.399	7.309
P	0.533	0.000	0.601	0.007	0.690	0.000

Note: MA group, Mechanical Aspiration group; SMA group, Syringe-Assisted Mechanical Aspiration group. Compared with before treatment within the same group, *P < 0.05.

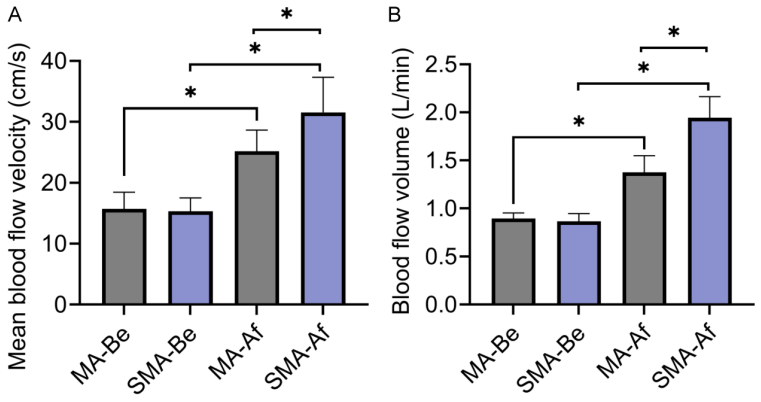

Figure 3. Comparison of hemodynamic parameters between the two groups. A. Average blood flow velocity; B. Blood flow volume. Note: Compared with before treatment within the same group, *P < 0.05. MA group, Mechanical Aspiration group; SMA group, Syringe-Assisted Mechanical Aspiration group.

Villalta score

Baseline Villalta scores did not differ significantly between the MA and SMA groups (P > 0.05). At 3 months post-treatment, both groups exhibited significant reductions in Villalta scores compared with baseline (P < 0.05). Moreover, post-treatment symptom scores, sign scores, and total scores in the SMA group were significantly lower than those in the MA group (P < 0.05), indicating superior alleviation of DVT severity with the combined therapy (**Table 5**).

Complications and thrombus recurrence

Within 3 months postoperatively, the overall complication rate was 16.00% (8/50) in the MA group and 11.29% (7/62) in the SMA group, with no statistically significant difference between groups (P > 0.05). Most complications were minor bleeding events, and no cases of severe or fatal bleeding or complications requiring surgical intervention occurred. The thrombus recurrence rate was 6.00% (3/50) in the MA group and 4.84% (3/62) in the SMA group, also showing no significant difference (P > 0.05). These results indicate that syringe-assisted aspiration combined with mechanical thrombectomy can enhance treatment efficacy without increasing bleeding risk or thrombus recurrence, demonstrating a favorable safety profile (**Table 6**).

Quality of life

Before treatment, there were no significant differences between the MA and SMA groups in GQOLI-74 scores across all dimensions (P > 0.05). After treatment, scores in all dimensions increased in both groups, with the SMA group showing significantly higher scores than the MA group (P < 0.05). These findings indicate that the combined treatment regimen can comprehensively improve patients' quality of life through superior symptom relief and functional recovery (**Table 7**).

Discussion

DVT is a common venous disorder in vascular surgery, with pathogenesis closely associated with venous stasis, endothelial injury, and hypercoagulable states. It frequently affects elderly patients, those undergoing surgery or trauma, individuals with malignancies, and pa-

Table 5. Comparison of Villalta scores between the two groups ($\bar{x} \pm s$, scores)

Group	Symptoms		Signs		Total score	
	Before treatment	3 months after treatment	Before treatment	3 months after treatment	Before treatment	3 months after treatment
MA group (n = 50)	12.10 ± 1.70	8.03 ± 1.45*	13.56 ± 1.52	7.11 ± 1.42*	24.87 ± 3.12	15.11 ± 2.32*
SMA group (n = 62)	12.25 ± 1.62	6.12 ± 1.20*	13.91 ± 1.33	6.24 ± 1.55*	25.12 ± 3.66	13.02 ± 1.87*
t	0.477	7.629	1.330	3.065	0.384	5.280
P	0.635	0.000	0.186	0.003	0.702	0.000

Note: MA group, Mechanical Aspiration group; SMA group, Syringe-Assisted Mechanical Aspiration group. Compared with before treatment within the same group, *P < 0.05.

Table 6. Comparison of complications and thrombosis recurrence between the two groups [n (%)]

Group	Complications				Recurrence
	Urinary tract bleeding	Puncture site bleeding	Gastrointestinal bleeding	Total	
MA group (n = 50)	3 (6.00)	2 (4.00)	3 (6.00)	8 (16.00)	3 (6.00)
SMA group (n = 62)	3 (4.84)	2 (3.23)	2 (3.23)	7 (11.29)	3 (4.84)
χ^2				0.529	0.023
P				0.467	0.880

Note: MA group, Mechanical Aspiration group; SMA group, Syringe-Assisted Mechanical Aspiration group.

Table 7. Comparison of quality of life scores between the two groups ($\bar{x} \pm s$, score)

Group	Physical function		Psychological function		Material life states		Social function	
	Before treatment	3 months after treatment	Before treatment	3 months after treatment	Before treatment	3 months after treatment	Before treatment	3 months after treatment
MA group (n = 50)	45.66 ± 6.12	56.11 ± 5.68*	46.15 ± 6.12	54.66 ± 5.14*	47.20 ± 6.55	57.20 ± 7.03*	48.22 ± 6.12	57.25 ± 5.12*
SMA group (n = 62)	45.17 ± 5.33	60.33 ± 5.89*	45.32 ± 6.04	57.89 ± 5.44*	46.33 ± 7.10	60.44 ± 5.26*	47.04 ± 7.20	61.20 ± 5.88*
t	0.453	3.830	0.719	3.201	0.672	2.789	0.921	3.741
P	0.652	0.000	0.474	0.002	0.503	0.006	0.359	0.000

Note: MA group, Mechanical Aspiration group; SMA group, Syringe-Assisted Mechanical Aspiration group. Compared with before treatment within the same group, *P < 0.05.

tients subjected to prolonged immobilization [10, 11]. Traditional clinical management of DVT primarily involves anticoagulation and thrombolysis, which can partially alleviate symptoms but are limited by suboptimal recanalization rates and a relatively high incidence of complications [12, 13]. With advances in interventional techniques, mechanical thrombectomy has increasingly become a standard treatment modality [14]. Building on this approach, syringe-assisted aspiration has emerged as an innovative adjunct, demonstrating promising clinical potential in recent practice [15].

In this study, the SMA group exhibited superior outcomes compared with the MA group across multiple parameters, including stent implantation, limb detumescence rate, thrombus clearance rate, thrombolytic drug dosage, hospitalization parameters, post-treatment limb circumference differences, venous patency scores, and Villalta scores. These results are consistent with the findings of Li W et al., who reported in a single-center retrospective analysis of 29 DVT cases that syringe-assisted aspiration combined with mechanical thrombectomy achieved a thrombus clearance rate exceeding 70%, with 86% of patients successfully treated in a single procedure [16]. This alignment supports the clinical efficacy and feasibility of the combined approach. These findings indicate that syringe-assisted aspiration combined with mechanical thrombectomy can significantly enhance the treatment efficacy of DVT. The underlying mechanism may involve a synergistic interplay between nega-

tive pressure, the pressure differential generated within the syringe, and mechanical forces that collectively improve the efficiency and precision of thrombus removal [17]. Specifically, retracting the syringe plunger creates negative pressure, establishing a vacuum that generates a substantial pressure gradient. This gradient facilitates the movement of blood and thrombus fragments into the syringe, effectively reducing thrombus burden and enabling rapid thrombus removal. Moreover, capillary action during aspiration aids the upward movement of fluid within the catheter, further accelerating thrombus removal. This technique employs a dedicated aspiration catheter that penetrates deeply into the thrombus, combining mechanical fragmentation with negative-pressure aspiration to achieve thorough thrombus clearance, thereby enhancing overall safety and efficacy. Mechanical thrombectomy, utilizing advanced suction pumps and precise catheter systems, can rapidly remove large thrombus volumes within a short period, effectively restoring vascular patency [18]. The mechanical aspiration pump allows for precise pressure control, ensuring procedural stability and safety. Additionally, these systems are typically equipped with advanced monitoring and feedback mechanisms, enabling real-time tracking of procedural parameters and providing clinicians with accurate operational guidance [19]. When combined, syringe-assisted aspiration and mechanical thrombectomy exert synergistic effects. By strategically coordinating the sequence and timing of syringe and mechanical aspiration, the advantages of both techniques can be maximized, optimizing procedural efficiency and overall treatment outcomes.

The occurrence and progression of DVT are closely associated with local hemodynamic abnormalities, often manifested as reduced blood flow velocity, disturbed flow patterns, changes in vessel diameter, and a hypercoagulable state [20]. In this study, post-treatment hemodynamic parameters in the SMA group were superior to those in the MA group, indicating that the combined approach more effectively restores hemodynamic function. The improvement may result from the synergistic effect of the two techniques, which enhances both procedural efficacy and safety. Syringe-assisted aspiration can function as a preparatory step before mechanical thrombectomy by partially removing thrombus and creating more favorable conditions for subsequent intervention. Mechanical thrombectomy then consolidates the effect of aspiration, ensuring complete vessel patency, increasing blood flow velocity and volume, and optimizing local hemodynamics [21]. Additionally, post-treatment quality of life scores were higher in the SMA group than in the MA group, indicating that the combined technique can further enhance patient quality of life. These benefits are primarily attributable to the precise efficacy of the procedure and the shorter postoperative recovery time. Regarding safety, no significant differences were observed between the groups in complication or thrombus recurrence rates, supporting the favorable safety profile of the combined approach. This can be explained by the precise control of aspiration, which minimizes injury to small vessels, and the rapid removal of thrombus fragments by mechanical thrombectomy, which reduces the risk of distal embolization and associated complications.

This study is a single-center retrospective analysis, which may be subject to inherent selection bias. The relatively small sample size could limit the statistical power, and the short follow-up period precluded assessment of long-term outcomes, such as post-thrombotic syndrome. Future large-scale, multicenter, prospective studies are needed to further validate these findings.

In summary, syringe-assisted aspiration combined with mechanical thrombectomy for lower extremity DVT demonstrates reliable efficacy. This approach effectively reduces thrombolytic drug usage and treatment duration, shortens hospital stay, lowers medical costs, improves hemodynamic parameters, and enhances patients' quality of life, while maintaining a favorable safety profile.

Disclosure of conflict of interest

None.

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