ORIGINAL ARTICLE

Study on clinical treatment of 30 cases of acute deep venous thrombosis

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Received: June 3, 2025 **Accepted:** August 30, 2025 **Online Published:** January 26, 2026
DOI: 10.5430/dcc.v11n3p1 **URL:** https://doi.org/10.5430/dcc.v11n3p1

ABSTRACT

Objective: To analyze the efficacy of the AngioJet thrombus aspiration system combined with catheter-directed thrombolysis (CDT) in treating acute deep venous thrombosis (ADVT).

Methods: Thirty patients with ADVT admitted to a tertiary A-grade hospital from January 2020 to March 2021 were randomly assigned to either the CDT group or the AngioJet group, with 15 patients in each group. The CDT group underwent catheter-directed thrombolysis, while the AngioJet group received the treatment with the AngioJet thrombus aspiration system. There were no statistically significant differences between the two groups in terms of gender, age, onset time, or thrombus type ($p > .05$). Thrombus clearance rates, limb edema resolution rates, total urokinase dosage, thrombolysis duration, and complications were compared between the two groups of patients with ADVT in this study.

Results: The AngioJet group demonstrated superior thrombectomy grading in comparison to the CDT group (Z = 2.340, $p = .019$). The limb edema resolution rate was significantly higher in the AngioJet group (93.33%) than that in the CDT group (53.33%) ($p < .05$). The thrombolysis duration in the AngioJet group (0.50 ± 0.11 h) was significantly shorter than that in the CDT group (72.14 ± 0.42 h) ($p < .05$). The urokinase dosage in the AngioJet group ($18.51 \pm 2.02 \times 10^4$ U) was significantly lower than that in the CDT group ($85.34 \pm 2.75 \times 10^4$ U) ($p < .05$). The incidence of complications in the AngioJet group (13.33%) was lower than that in the CDT group (26.67%), with no statistically significant difference ($p > .05$).

Conclusions: The AngioJet thrombus aspiration system demonstrates superior thrombus clearance efficacy in comparison to CDT in ADVT patients, with shorter thrombolysis duration, reduced urokinase dosage, and favorable clinical safety.

Key Words: Acute deep venous thrombosis, Catheter-directed thrombolysis, AngioJet thrombus aspiration system, Thrombus clearance rate

1. INTRODUCTION

Acute deep venous thrombosis (ADVT) is a common clinical condition characterized by the formation of blood clots within the veins of the lower extremities, obstructing blood flow. This results in symptoms such as swelling and pain in unilateral lower extremity, significantly impacting patients daily life. Some studies indicate that early-stage thrombosis formation presents no obvious symptoms. If patients do not receive timely, scientifically effective treatment, symptoms such as lower extremity swelling, skin pigmentation, superficial varicose veins in the lower extremities, and chronic eczema may develop, ultimately leading to post-thrombosis

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syndrome (PTS).[1] Clinical treatment often involves anticoagulant therapy, which effectively inhibits thrombus progression and reduces the incidence of pulmonary embolism. However, in spite of standard anticoagulant treatment, approximately half of patients still develop PTS within two years,[2] presenting with symptoms such as lower extremity edema and diminishing treatment efficacy. Catheter-directed thrombolysis (CDT) effectively improves the deep venous patency rate and prevents the occurrence of PTS. However, this method involves relatively prolonged catheter placement time, requires higher urokinase dosage, and results in longer hospital stays,[3] presenting suboptimal safety in clinical application. With the rapid advancement of endovascular techniques, the AngioJet thrombus aspiration system has gained a widespread clinical application. It effectively clears thrombi while administering thrombolytic agents, requiring relatively lower drug dosage, shorter treatment duration, and lower bleeding risks.[4] This study enrolled 30 patients with ADVT to compare the efficacy of the CDT system with the AngioJet thrombus aspiration system. The details are as follows.

2. Data and Methods

2.1 Clinical data

A total of 30 patients with ADVT admitted to a tertiary A-grade hospital from January 2020 to March 2021 were enrolled. Using a random number table, they were divided into the CDT group (n = 15) and the AngioJet group (n = 15). The CDT group comprised 7 males and 8 females, aged 41 to 67 (mean: 54.24 $\pm$ 3.57). The onset time ranged from 1 to 14 days (mean: 7.03 $\pm$ 0.95 days). clocations included: iliac vein (4 cases), femoral-popliteal vein (5 cases), and mixed type (6 cases). The AngioJet group comprised 9 males and 6 females, aged 40 to 69 (mean: 55.37 $\pm$ 3.61); the onset time ranged from 2 to 14 days (mean 7.29 $\pm$ 1.27 days). Thrombosis locations included: iliac vein (6 cases), femoral-popliteal vein (4 cases), and mixed type (5 cases). There were no statistically significant differences between the two groups in terms of gender, age, onset time, or thrombus type (p > .05) (see Tables 1-4).

2.2 Inclusion/Exclusion criteria

Inclusion criteria: (1) Upon admission, the patient and their family were informed of the study details; (2) The patient and their family members signed the informed consent form; (3) patients who met the diagnostic criteria outlined in the "Guidelines for the Diagnosis and Treatment of Deep venous Thrombosis (Third Edition);"[5] (4) patients with acute deep venous thrombosis. Exclusion criteria: (1) patients with severe cardiovascular and cerebrovascular diseases; (2) patients with Cooket syndrome and positive results of antiphospholipid antibodies; (3) patients who were breastfeeding or pregnant; (4) patients who discontinued the treatment.

Table 1. Gender distribution in the AngioJet and CDT groups (n = 15)

Group		AngioJet Group	CDT Group	*p* value
Gender (n)	Male	9	7	.657*
	Female	6	8	

Note. * The use of Fisher's exact probability test.

Table 2. Age distribution in the AngioJet Group and CDT group (n = 15)

Group	AngioJet Group	CDT Group	χ^2/*t* value	*p* value
Age ($\bar{x}$±s)	55.37±3.61	54.24±3.57	0.635	.396

Table 3. Comparison of onset time between the AngioJet Group and the CDT group (n = 15)

Group	AngioJet Group	CDT Group	χ^2/*t* value	*p* value
Onset Time (d, $\bar{x}$±s)	7.29±1.27	7.03±0.95	0.635	.531

Table 4. Comparison of thrombosis locations between the AngioJet group and the CDT group (n = 15)

Group		AngioJet Group	CDT Group	*p* value
Thrombosis Location (*n*)	Mixed Type	5	6	.740*
	Iliac Vein	6	4	
	Femoral-Popliteal Vein	4	5	

Note. * The use of Fisher's exact probability test.

2.3 Methods

Upon admission, both groups of patients received anticoagulant therapy. A catheter needle was indwelling in the dorsum vein of the affected foot. Patients were positioned supine. After successful puncture of the common femoral vein on the unaffected side with Seldinger technique, inferior vena cava angiography was performed with a vena cava filter placed. The AngioJet thrombus aspiration system was employed to the AngioJet group. After manual contrast injection via the dorsum vein of the affected foot, either an anterior tibial vein puncture or an ultrasound-guided popliteal vein puncture was performed. A 6F sheath was inserted, or the catheter was advanced transvenously from the contralateral femoral vein into the patient's deep vein for venography to assess thrombus extent. A guidewire and a catheter were advanced through the thrombus segment, with the guidewire tip positioned in the inferior vena cava or distal popliteal vein. The AngioJet thrombus aspiration system was then used to spray 200,000 units of urokinase (Nanjing Nanda Pharmaceutical Co., Ltd.) into the site. After 30 minutes, thrombus aspiration was performed. Follow-up angiography review, combined with the patient's clinical condition, may allow multiple aspirations of residual wall-adherent thrombus, with a total aspiration time $\leq$ 480 seconds.

The CDT group received CDT therapy with a 5F multi-lumen perfusion catheter indwelling, connected to a microinfusion pump. Urokinase at 1×10^4U/(kg·d) diluted in 48 mL saline was infused at 10 mL/h into the sheath-venous circuit. Standard heparin was administered for 24 hours to maintain activated partial thromboplastin time (APTT) between 60–80 seconds. When fibrinogen (Fb) was < 1.5 g/L, urokinase dosage was halved; when Fb was < 1.0 g/L, urokinase infusion was discontinued. Thrombolysis efficacy was assessed via iliofemoral and lower extremity venography 2–4 days post-treatment.[6]

If both groups exhibit > 50% iliac vein stenosis with impaired venous return after treatment, balloon dilatation followed by venous stent implantation was performed.[7] Once the thrombus has been completely cleared, the inferior vena cava filter was then removed.

After treatment, both groups received low molecular weight heparin anticoagulation for one week, after which they were switched to a novel anticoagulant such as rivaroxaban for at least three months.

2.4 Observation indicators

(1) The thrombus clearance rates were compared between the two groups. Combining the two groups of cases, the results of venography performed immediately after thrombus aspiration in the AngioJet group and after catheter-directed thrombolysis in the CDT group were evaluated prior to initiating the treatment following successful deep venous catheterization. The iliac vein, femoral vein, popliteal vein, and other segments were assessed, with complete recanalization, partial recanalization, and occlusion scores of 0, 1, and 2, respectively. The total score comprised the sum of segment scores before and after thrombus aspiration. Thrombus clearance rates can be classified into three grades: Grade 1: < 50% recanalization, Grade 2: 50%–95% recanalization, Grade 3: $\geq$ 96% recanalization.

(2) The edema resolution in the affected limbs was compared between the two groups. Thigh circumference: 15 cm above the patella; lower leg circumference: 10 cm below the patella. The circumference difference of the affected limb (preoperative, postoperative, and after catheter-directed thrombolysis) was calculated, and the edema resolution rate = (post-thrombolysis circumference difference/pre-thrombolysis circumference difference) $\times$ 100%.[8]

(3) The treatment-related indicators (total urokinase dosage and thrombolysis duration) were compared between the two groups.

(4) The incidence of complications, including bleeding, vomiting, pulmonary embolism, and recurrence of ADVT, were compared between the two groups.

2.5 Statistical analysis

Statistical analysis was performed by use of SPSS 23.0 software. Categorical data were expressed as cases (%). Fisher's exact test was used for comparison. Measurement data were presented as mean $\pm$ standard deviation ($\bar{x}\pm$s). An independent-samples t test was used for inter-group comparisons. Ranked data were analyzed by use of the rank sum test. p < .05 was considered statistically significant.

3. RESULTS

3.1 Thrombus clearance rate and limb edema resolution rate in two groups

The AngioJet group demonstrated superior thrombectomy grading in comparison to the CDT group (Z = 2.340, p = .019). The rate of limb edema resolution in the AngioJet group (93.33%) was significantly higher than that in the CDT group (53.33%), with a statistically significant difference (p < .05) (see Tables 5-6).

3.2 Comparison of urokinase dosage and thrombolysis duration between two groups

The AngioJet group demonstrated significantly shorter thrombolysis duration and lower urokinase dosage in comparison

to the control group ($p < .05$) (see Table 7).

3.3 Incidence rate of complications in the two groups

The AngioJet group compromised 2 complications, with an incidence rate of 13.33%, including 1 case of bleeding and 1 case of recurrent DVT. The CDT group compromised 4 complications, with an incidence rate of 26.67%, including 1 case of bleeding, 1 case of vomiting, and 2 cases of recurrent DVT. The Fisher's exact probability test yielded $p = .65$, indicating no statistically significant difference.

Table 5. Thrombus clearance rate in the AngioJet group and the CDT group ($n = 15$) [cases (%)]

Edema Resolution	Grade 1	Grade 2	Grade 3
AngioJet Group	0 (0.00)	3 (20.00)	12 (80.00)
CDT Group	2 (13.33)	8 (53.33)	5 (33.33)
Z value		2.340	
p value		.019	

Table 6. Comparison of edema resolution rate in the affected limb between the AngioJet group and the CDT group ($n = 15$) [Cases (%)]

Group	AngioJet Group	CDT Group	*p* value
Edema Resolution Rate	14 (93.33)	8 (53.33)	.035*

Note. * The use of Fisher's exact probability test.

Table 7. Comparison of urokinase dosage and thrombolysis duration between the AngioJe group and the CDT group ($n = 15$) ($\bar{x}\pm$s)

Group	AngioJet Group	CDT Group	*t* value	*p* value
Urokinase Dosage ($\times 10^4$ U)	18.51±2.02	85.34±2.75	75.855	< .001
Thrombolysis Duration (h)	0.50±0.11	72.14±0.42	639.066	< .001

4. Discussion

ADVT ranks as the third most common vascular disease after cardiovascular and cerebrovascular diseases, predominantly affecting lower limb vessels. The annual incidence of ADVT ranges from 45 to 117 per 100,000 people, while that of pulmonary embolism (PE) is 28 to 79 per 100,000.[9] Both conditions carry high mortality rates. According to statistics, the mortality rate within one month of confirmed ADVT is approximately 6%, while that of PE reaches as high as 10%. Within the first 12 months following the diagnosis of venous thromboembolism (VTE), the mortality rate stands at 5%.[10] In addition to PE, ADVT complications include recurrent thrombosis (affecting 30% of patients within 10 years of onset) and PTS (affecting 20% to 50% of patients who develop ADVT).[11] In addition, ADVT complications include recurrent thrombosis and PTS. PTS can cause persistent swelling and soreness in the lower extremities, superficial varicose veins, skin pigmentation, chronic phlebitis, ulcers, and other conditions. Treatment is difficult, causing patients significant distress and severely impacting their quality of life. Therefore, timely, effective, standardized diagnosis and treatment are of paramount importance. ADVT is a clinically common disease caused by impaired venous return in the lower extremities. It manifests as edema and distending pain in the affected limb, with high tissue tension and pitting edema. The location of edema varies significantly depending on the site of thrombosis. Approximately 80% of patients experience no significant discomfort at the onset of the disease, missing the window for early treatment. As the condition progresses, it gradually triggers multiple complications. The primary clinical treatment approach involves anticoagulation therapy; however, anticoagulation alone cannot eliminate thrombi, leading to PTS and diminishing patients' long-term quality of life. The control group in this study demonstrated that CDT could rapidly clear thrombi and reduce the long-term incidence of PTS. However, this method requires high dosage of thrombolytic agents and frequent angiography, posing clinical safety concerns, particularly for older patients with hypertension or gastrointestinal diseases. Additionally, it necessitates close monitoring, repeated blood tests, prolonged thrombolysis duration, high drug dosages, and carries a significant risk of bleeding.[2] Therefore, for patients with ADVT, enhancing clinical safety and improving thrombus clearance rates are particularly important.

To further enhance therapeutic efficacy, the AngioJet thrombus aspiration system, a widely used thrombus removal

device in clinical practice, was employed to the AngioJet group in this study. This system combines both thrombolytic and thrombectomy functions, requiring significantly lower dosage of urokinase while achieving faster thrombus clearance. Theoretically, it offers superior performance in comparison to CDT. Results showed that the AngioJet group had significantly lower urokinase dosage and thrombolysis duration in comparison to the CDT group. The AngioJet group demonstrated a higher thrombus clearance rate than the CDT group, with a limb edema resolution rate of 93.33%, which was 53.33% higher than that of the CDT group. Similar to the findings of Zhao Qinming et al.,[3] this study suggests that the method demonstrates favorable thrombolytic efficacy in treating acute venous thrombosis (AVT). Compared with conventional thrombolytic therapy, it achieves thrombolysis in a shorter timeframe and yields a higher rate of venous patency. This system utilizes the Bernoulli effect by spraying urokinase firstly to soften the thrombus, then breaking it down with high-velocity water flow and suctioning it out of the body. It rapidly reduces thrombus burdens, improves venous valve function, causes minimal damage to the vascular endothelium, and enhances patients' long-term quality of life. Additionally, the system is easy to operate. After establishing the access route, a stiffened guidewire can be advanced through the thrombotic segment in conjunction with the catheter, enabling thrombolysis and thrombus extraction procedures. The results of this study indicate that the incidence of complications in the AngioJet group (13.33%) was slightly lower than that in the CDT group (26.67%), but the difference was not statistically significant, likely due to the relatively small sample size. The AngioJet thrombus aspiration system is a safe and effective mechanical thrombus aspiration device, as demonstrated in the research findings of Niu Qibing et al.[12] However, the following points should be noted when applying this system: (1) Injecting urokinase prior to aspiration can effectively enhance the thrombolysis rate; (2) If thrombus clearance is suboptimal, the addition of CDT can further improve thrombus clearance efficacy; (3) Even in cases with short onset duration and near-complete aspiration, recurrence cannot be ruled out. Follow-up angiography or color Doppler ultrasound should be performed 2 days postoperatively; (4) The maximum aspiration duration should not exceed 8 minutes, as prolonged aspiration may exacerbate damage to blood cells and the vascular endothelium. Any residual mural thrombus can be further cleared by subsequent anticoagulant therapy; (5) Using an 8F thrombus aspiration catheter in iliofemoral vein thrombosis yields superior thrombus removal efficacy.

5. Conclusions

The AngioJet thrombus aspiration system demonstrates superior efficacy in comparison to CDT in patients with ADVT. It achieves thrombolysis in a shorter timeframe, requires lower dosage of urokinase, and offers a safe and reliable treatment option that effectively reduces the edema resolution rate in the affected limb.

Acknowledgements

Not applicable.

Authors contributions

Bo Han contributed to the study design and argumentation; Junjie Wang contributed to the literature search, data acquisition and organization, data analysis, statistical analysis and the manuscript drafting.

Funding

The study was funded by the Baotou Science and Technology Plan Project (No. 2020Z1009-10).

Conflicts of Interest Disclosure

The authors delcare no conflicts of interest.

Informed consent

Obtained.

Ethics approval

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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