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Catheter-Mediated Selective Thrombolysis and Anticoagulant Therapy for Deep Vein Thrombosis: Analysis of Efficacy, Safety and Clinical Outcomes

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Abstract: Background: Deep vein thrombosis (DVT) is an important component of venous thromboembolism and can lead to pulmonary embolism with high morbidity and mortality. Anticoagulant therapy alone (ACA) and catheter-mediated thrombolysis (CDT) are commonly used strategies for the management of DVT. Although CDT has been reported to be effective in reducing the risk of postthrombotic syndrome (PTS), it remains unclear in which patient groups it should be preferred due to the risk of bleeding. **Methods:** This retrospective study included 175 patients diagnosed with DVT between 2015 and 2024 (98 ACA, 77 CDT). Patients with a diagnosis of proximal DVT, aged ≥18 years and with at least 30 days of follow-up data were included. The primary endpoint was 30-day mortality and secondary endpoints were length of hospitalization, pulmonary embolism and bleeding complications. **Results:** The CDT group was superior to ACA in thrombus clearance rates, especially in iliac vein thrombosis (97.7% vs. 78%, p=0.003). Clinical symptoms improved faster in the CDT group, but total hospitalization was longer. There were no significant differences in bleeding complications and mortality rates between the two groups. **Conclusion:** The optimal approach to DVT treatment should be based on the patient's individual risk factors. Although CDT provides a higher thrombus clearance rate, especially in iliac vein thrombosis, it may not be suitable for all patients. Future large-scale studies will contribute to a better understanding of the long-term outcomes of interventional therapies.

Keywords: Catheter-mediated thrombolysis; deep vein thromboembolism; anticoagulation

1. Introduction

Deep vein thrombosis (DVT) represents a major clinical manifestation of venous thromboembolism (VTE) and serves as a significant precursor to pulmonary embolism (PE), contributing substantially to both morbidity and mortality [1]. VTE is the third most common cause of death among cardiovascular diseases worldwide and constitutes a significant risk factor, especially for hospitalized patients [2]. The emergence of the COVID-19 pandemic has significantly amplified the clinical burden of venous thromboembolism (VTE), thereby underscoring the urgent need for more effective and evidence-based therapeutic strategies to optimize patient management [1].

The main approaches to the treatment of DVT include anticoagulant therapy (ACA) and catheter-mediated thrombolysis (CDT). ACA prevents the clot from growing, allowing time for the body's natural fibrinolytic system, while CDT aims to directly dissolve the thrombus, which may provide faster clinical improvement [2]. However, uncertainties persist concerning the long-term efficacy and safety of both methods. CDT has been reported to may preserve the venous function,

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reduce the risk of postthrombotic syndrome (PTS) (the "open-vein hypothesis") and improve quality of life, especially in patients with proximal DVT [3,4]. However, it is still controversial in which patient groups CDT should be preferred because it is a more invasive method and involves an inherent risk of hemorrhage [5].

Studies on the prevalence and incidence of DVT reveal that the global health impact of this disease is increasing and risk factors need to be better understood [6]. Current guidelines recommend individualized treatment approaches and emphasize that optimal treatment should be selected based on the patients' thrombotic burden, symptom duration and general health status [2]. Recent studies on the efficacy of antithrombotic therapies suggest that combined treatment strategies may be considered to reduce complication rates [7].

In this study, we compared the clinical outcomes of CDT and ACA-only groups in patients diagnosed with DVT. By analyzing the efficacy, safety and effects of treatment approaches on the development of PTS, it was evaluated which patient group could benefit more from which treatment method. Thus, we aimed to provide evidence-based data that may contribute to reducing the global health burden of VTE.

2. Material and Methods

2.1. Study Design

This is a retrospective study in which the data of patients who were treated for DVT between 2015 and 2024 were retrospectively analyzed. Approval for the study was obtained from Human Research Ethics Committee of Ankara University School of Medicine (Date: 26 March 2025, No. 2025/269) A total of 175 patients were included in the study, 98 of whom were treated with ACA and 77 with CDT.

Patients who were 18 years of age or older, diagnosed with proximal DVT of the lower extremities and had at least 30 days of follow-up data were included in the study. Patients with stable general condition, low bleeding risk and life expectancy of at least one year were included. Patients who had received thrombolytic therapy for pulmonary embolism, patients with active bleeding or severe bleeding risk, patients with a history of previous lower extremity venous surgery, and patients in pregnancy or postpartum period were excluded.

2.2. Outcomes

The primary endpoint of the study was postoperative 30-day mortality. Secondary endpoints were defined as intensive care unit length of stay, total hospital stay, pulmonary embolism, major and minor bleeding. Major bleeding was defined as fatal bleeding, symptomatic intracranial bleeding, bleeding causing hemodynamic instability, or bleeding requiring surgical intervention or ≥2 units of blood transfusion. Minor bleeding was defined as any clinically significant bleeding event that did not meet the criteria for major bleeding, such as small hematomas, mild hemoptysis or minor mucosal bleeding not requiring medical intervention.

2.3. Treatment Protocol

Patients receiving only anticoagulant therapy received intravenous unfractionated heparin infusion. Heparin infusion was administered with dose adjustment so that the aPTT value was 1.5-2.5 times. After the procedure was completed, all patients received full dose anticoagulation therapy and the duration of treatment was planned to be at least 3 months. The duration of treatment was determined according to the individual thromboembolic risk factors of the patients.

Patients in the CDT group underwent ultrasound-guided venous access and catheter placement. The popliteal vein was determined as the main access route due to factors such as increasing experience over time, the ease of ultrasound-guided vascular access and the shortness of the procedure. In cases where the popliteal vein was not suitable, the femoral vein or the vena saphena

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parva were used as alternative access routes. Small saphenous vein catheterization was preferred in cases where the popliteal vein was deep or the attempt was unsuccessful. In popliteal vein catheterization, patients were placed in the prone position and a 5F catheter was inserted into the popliteal vein under ultrasound guidance. A 0.035-inch hydrophilic guidewire was then advanced along the thrombotic segment and a multiple side-bore infusion catheter (Cook Medical, Bloomington, IN, USA) was inserted into the thrombotic lesion. In femoral vein catheterization, a 5F catheter was inserted into the femoral vein under ultrasound guidance in supine patients and a multiple side bore infusion catheter (Cook Medical, Bloomington, IN, USA) was positioned to reach the iliocaval junction for catheter-mediated thrombolysis. Alteplase (ACTILYSE® Boehringer Ingelheim, Germany) was infused through the catheter as a thrombolytic agent. The dose of alteplase was 20 mg intravenous bolus followed by intravenous infusion of 0.5-1 mg/hour for 24 hours. After the procedure, patients were closely monitored in the intensive care unit and hemodynamic parameters and bleeding complications were evaluated. Anticoagulant therapy was initiated in all patients during the post-thrombolysis period.

Bleeding complications were monitored for 96 hours after the procedure. During the post-discharge follow-up period, patients were invited to outpatient clinic visits at regular intervals. The first follow-up visit was performed at 1 month post-discharge, followed by follow-up visits at 3, 6 and 12 months. During the follow-up period, clinical symptoms, DVT-related complications and development of post-thrombotic syndrome were evaluated. At each follow-up visit, in addition to physical examination, the venous system was evaluated by Doppler ultrasonography (USG) for the presence of recanalization and recurrent thrombosis. Patients' compliance with anticoagulant therapy was also evaluated.

Therapy was ceased once thrombus removal reached at least 90%, with concurrent restoration of perfusion and recorded as “thrombus removal rate”. The thrombus removal rate serves as an indicator of the extent of thrombus dissolution following both treatment modalities. In our study, thrombus resolution was assessed at predefined intervals using Doppler ultrasonography. This imaging modality was preferred due to its non-invasive nature and its capability to provide a visual evaluation of venous blood flow and the presence of thrombus. During the follow-up period, thrombus resolution was defined based on the recanalization of thrombosed segments and the recurrence of thrombosis.

2.4. Statistical Analysis

Statistical analyses were conducted to evaluate differences between the two treatment groups—ACA and CDT—across several outcome measures. Continuous variables were expressed as mean ± standard deviation (SD), providing a measure of central tendency and variability for the data. These variables were compared using the t-test, which is appropriate for comparing means between two independent groups. The t-test assumes normal distribution and equal variance between groups, which is typically verified through exploratory data analysis (e.g., normality tests and variance checks).

Categorical variables, which include outcomes such as the incidence of complications (e.g., gastrointestinal bleeding, PE), were presented as frequencies and percentages. For comparisons between these categorical variables, the Fisher’s exact chi-square test was employed. The chi-square test is commonly used to assess associations between two categorical variables, but in cases where the expected cell frequencies are low (typically less than 5), Fisher's exact test provides a more accurate result. This ensures the validity of statistical inference, especially when working with small sample sizes or sparse data in contingency tables.

The IBM SPSS version 20.0 software program was used to conduct the analyses, a well-established statistical tool in medical research. For all statistical tests, a p-value < 0.05 was considered indicative of statistical significance, meaning there was strong evidence to reject the null hypothesis that no difference exists between the groups.

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3. Results

175 patients with DVT were included in the study, of which 98 were given ACA and 77 received CDT. Baseline demographics of both the groups were similar to one another, enabling a fair comparison between the treatment strategies (Table 1).

Table 1. Baseline characteristics of the patients.

Characteristics	ACA(n=98)	CDT(n=77)	p-value
Age(year,mean)	57.2	54.3	0.954
Male	44(44.8%)	35(45.4%)	0.501
Diabetes mellitus	10(10.2%)	7(9%)	0.687
BMI>30	19(19.3%)	22(28.5%)	0.32
Hypertension	41(41.8%)	32(41.5%)	0.345
Cerebrovascular accident	3(3%)	2(2.5%)	0.144
Smoking	33(33.6%)	24(31.1%)	0.309
Hyperlipidemia	23(23.4%)	22(28.5%)	0.211
Malignancy	9(9.1%)	8(10.3%)	0.103
Previous DVT	9(9.1%)	5(6.4%)	0.077
Thrombophilia	20(20.4%)	13(16.8%)	0.193

The PE rate was comparable in the two groups, as it was observed in 8.1% of the ACA group and 7.7% of the CDT group (p = 0.332). The occurrence of gastrointestinal bleeding (2% vs. 3.8%, p = 0.789) and intracranial hemorrhage (1% vs. 3.8%, p = 0.45) did not differ significantly too, demonstrating that CDT did not increase the risk of major bleeding complications. Hematoma occurred in 1% of ACA patients and 2.5% of CDT patients (p = 0.988), once more validating the safety profile of both therapies. Mortality was low in both groups (1% in ACA vs. 2.5% in CDT, p = 0.707) and did not differ statistically significantly (Table 2).

Table 2. Outcomes of Patients Undergoing ACA or CDT Groups.

Outcome	ACA(n=98)	CDT(n=77)	p-value
Pulmonary embolism	8(8.1%)	6(7.7%)	0.332
Gastrointestinal Bleed	2(2%)	3(3.8%)	0.789
Intracranial hemorrhage	1(1%)	3(3.8%)	0.45
Hematoma	1(1%)	2(2.5%)	0.988
Death	1(1%)	2(2.5%)	0.707

Data are presented as n (%) or mean ± standard deviation. ACA: anticoagulation therapy alone, CDT: catheter-directed thrombolysis.

Thrombus distribution analysis revealed no statistically significant difference in both groups. The most frequently affected venous segments were the femoral vein (79.5% in ACA vs. 80.5% in CDT, p = 0.189) and the popliteal vein (74.4% in ACA vs. 66.2% in CDT, p = 0.307). Iliac vein thrombosis was more common in the CDT group (58.4% vs. 41.8% in ACA, p = 0.705), while calf vein involvement was present in approximately one-third of the patients in both groups (33.6% vs. 27.2%, p = 0.605). Inferior vena cava thrombosis was not very prevalent but was present in 4% of the ACA patients and 6.4% of the CDT patients (p = 0.669) (Table 3).

Table 3. Thrombus localization.

Lesion	ACA(n=98)	CDT(n=77)	p-value

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Inferior vena cava	4(4%)	5(6.4%)	0.669
Iliac vein	41(41.8%)	45(58.4%)	0.705
Femoral vein	78(79.5%)	62(80.5%)	0.189
Popliteal vein	73(74.4%)	51(66.2%)	0.307
Calf vein	33(33.6%)	21(27.2%)	0.605

Data are presented as n (%) or mean ± standard deviation. ACA: anticoagulation therapy alone, CDT: catheter-directed thrombolysis.

One of the principal findings of the study was the significantly higher rate of thrombus removal in the CDT group, particularly in iliac vein thrombosis.It was also observed that the clinical symptoms resolved more quickly in this group. Thrombus resolution was achieved in 97.7% of CDT patients compared with 78% in the ACA group (p = 0.003), which was a clear advantage of CDT in this vascular territory. Although the rates of thrombus removal were also slightly higher in the CDT group for both femoral (91.1% vs. 92.3%, p = 0.081) and popliteal veins (80.3% vs. 91.7%, p = 0.318), there were no significant differences. Clearance of thrombus of calf veins was similar in both groups (81% in ACA vs. 85.7% in CDT, p = 0.345). Interestingly, in patients who had inferior vena cava thrombosis, complete thrombus removal was observed in all cases regardless of treatment modality (100% in both groups, p = 0.869) (Table 4). This would suggest that for more central thrombi, both CDT and ACA can be very effective.

Table 4. Thrombus removal rate.

Lesion	ACA(n=98)	CDT(n=77)	p-value
Inferior vena cava	4(100%)	5(100%)	0.869
Iliac vein	32(78%)	44(97.7%)	0.003
Femoral vein	72(92.3%)	57(91.1%)	0.081
Popliteal vein	67(91.7%)	41(80.3%)	0.318
Calf vein	27(81%)	18(85.7%)	0.345

Data are presented as n (%) or mean ± standard deviation. ACA: anticoagulation therapy alone, CDT: catheter-directed thrombolysis.

4. Discussion

Besides conventional anticoagulant therapy, the efficacy of interventional procedures such as CDT and mechanical thrombectomy for the management of DVT has been investigated for a long time. The results of our research, in conjunction with the existing literature, will be of great importance in determining the efficacy and complication rates of the different techniques.

CDT is also known to be a highly effective technique for prevention of development of PTS, particularly in acute iliofemoral DVT patients with low risk of major bleeding and in patients with acute iliofemoral DVT (<14 days) and low risk of bleeding. The CAVENT study proved that target vessel patency was maintained in a better way and the rate of PTS decreased among patients treated with CDT [8]. Widespread application of CDT might be hindered by major bleeding caused by thrombolytic agents. The ATTRACT study clarified that although CDT alleviated symptoms of thrombosis in the acute phase, it did not have any major effect on the occurrence of PTS in the long run [9]. These findings emphasize that CDT should be employed with appropriate patient selection.

Mechanical thrombectomy is now a much-sought-after treatment for DVT. The DEFIANCE trial showed that mechanical thrombectomy provided faster clot removal compared to anticoagulation therapy alone but was not linked with a considerable difference in long-term venous patency and onset of PTS [10]. However, other research has pointed out that the addition of CDT to mechanical thrombectomy can produce better clinical outcomes [11,12].

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As indicated in Makedonov et al.'s study, pharmacomechanical thrombolysis, especially when combined with endovenous methods, not only reduces clot clearance time but also minimizes bleeding risk through the reduction of the systemic thrombolytic dose [13]. The intervention has the additional advantage of long-term preservation of venous function, especially in active and young patients. The research demonstrated reduced PTS rates compared to conventional anticoagulation therapy. These findings suggest that the addition of mechanical procedures to CDT can enhance its efficiency even further.

Ultrasound-guided interventional procedures also have an important part to play in the treatment of DVT. It has been shown that ultrasound-guided interventions can be better than conventional methods in terms of preserving venous patency [3,14]. Some studies have also shown that early intervention procedures are associated with lower rates of PTS [5,15]. As per the study by Thukral et al., the application of early endovenous treatments in DVT management was emphasized to realize not just symptom alleviation but also a significant effect on quality of life. The study is particularly relevant because of its potential to reduce hospitalization and total health costs. It was further mentioned that these interventions could be particularly effective in the iliofemoral segment with minimal complication rates. This would mean that invasive interventions are not merely economically but also clinically reasonable options [15].

The results of our research emphasize patient-specific tailored treatment approaches in accordance with the literature. Especially in high-risk patients, interventional therapies such as CDT and mechanical thrombectomy should be carefully selected and long-term results of these methods should be investigated [2,13]. In addition, patient compliance and persistence of anticoagulant therapy on follow-up of DVT are significantly important to reduce recurrence rates [6,15]. Dicks et al.'s study shows that individualization of interventional treatment options by using sophisticated imaging techniques can optimize treatment outcomes while also reducing complication rates [14].

In the paper, it was stated that diagnostic tools like ultrasound and MR venography utilized in the management of DVT have a determining role in the selection of patients and provide significant contributions particularly in the early diagnosis of complications like subclinical pulmonary embolism. In this regard, it is realized that not just the forms of treatment but also the supportive methods applied in the decision-making process must be optimized.

The global burden on health caused by DVT should also be considered. DVT prevalence is seen to be on the increase, and VTE remains one of the leading causes of morbidity and mortality across the world [1,14]. This once again highlights the importance of early diagnosis and optimal treatment practices. Individualized approaches are of paramount importance in the management of DVT. A management strategy needs to be developed based on the clinical status, risk factors and patient profile. Interventional techniques such as anticoagulant therapy, CDT, and mechanical thrombectomy can each be beneficial in selected patient groups. However, long-term follow-up trials in larger patient groups are needed to further understand the efficacy and long-term outcomes of these methods.

4.1. Study Limitations

Our study has some limitations. First of all, its retrospective design limits causal relationships. The single center of the study may also affect the generalizability of the results to other institutions or regions. Second, the lack of randomization may lead to some decisions that affect treatment decisions. As the follow-up period was up to 12 months, it is difficult to detect long-term complications such as post-thrombotic syndrome. Another reason is that our study excluded high-risk patients, which limits its applicability to these populations. Lastly, inconsistencies may have occurred due to variability in CDT procedural techniques, affecting the comparability of the results.

5. Conclusion

The optimal approach to DVT treatment should be determined according to the individual risk factors and clinical condition of the patient. Although interventional methods may be effective in

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certain patient groups, they may not be appropriate for all patients. Therefore, future large-scale and long-term studies will contribute to a better understanding of the efficacy of treatment methods. Our study is important in terms of contributing to the existing literature and reveals issues that need to be supported with larger patient populations in the future.

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