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Shifting Paradigms in Deep Vein Thrombosis: A Prospective Cohort Evidence for Catheter-Directed Thrombolysis Versus Anticoagulation

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ABSTRACT

Venous thromboembolism (VTE) is the third leading cause of death among cardiovascular diseases and poses a significant danger, especially for hospitalised patients. The global influence of DVT on health is a further consideration that must be acknowledged. The prevalence of deep vein thrombosis (DVT) is increasing, and venous thromboembolism (VTE) remains a significant worldwide health issue. This further substantiates that timely diagnosis and efficient treatment are essential. Deep vein thrombosis (DVT) is the result of around two-thirds of venous thromboembolism (VTE) cases, while PE is the primary symptom of the remaining one-third. Although DVT is usually associated with hospitalised patients, over two-thirds of cases actually occur in outpatient settings. Heredity, advanced age, hypercoagulable diseases (like cancer), and temporary situations (like medication, bed rest, hospitalisation, travel, and trauma) are among the factors that raise the risk of blood clots. When many variables interact and may have a cumulative effect, the likelihood of mortality may increase. Despite intensive attempts to identify and quantify DVT dangers, a substantial fraction of DVT cases—up to 20%—are classified as idiopathic, meaning no discernible risk factor has been identified. Because of this, DVT is an extremely difficult disease to predict and prevent. The management of deep vein thrombosis (DVT) is predominantly based on personalised approaches. The patient's profile, clinical condition, and risk factors must guide the formulation of a care strategy. Specific patient groups may get advantages from interventional techniques such as mechanical thrombectomy, catheter-directed thrombolysis (CDT), and anticoagulant therapy. CDT intervention involves assessing the costs and risks against the benefits of minimising PTS and reoccurring DVT. Due to its long-term benefits, CDT is best for patients with IFDVT and other severe thromboses at high risk for recurrence and/or PTS, as well as those with a long life expectancy and minimal comorbidities. Three medical associations advocate CDT for DVT.All CDT recommendations advocate using it with anticoagulation. To ascertain the efficacy and enduring consequences of these methodologies, larger patient cohorts must engage in longitudinal follow-up investigations.

***Keywords**: Venous Thromboembolism (VTE), Catheter –Directed Thrombolysis (CDT), Anticoagulation (AC), Deep Vein Thrombosis (DVT), Iliofemoral Deep Vein Thrombosis (IFDVT).*

Introduction

Venous thromboembolism includes PE and DVT. With 1-2 cases per 1,000 Americans annually, VTE is a serious public health issue. PE causes most VTE fatalities. Over 80% of PE cases are caused by leg or pelvic blood clots. Clots travel through veins to the heart and pulmonary arteries.VTE kills at least 100,000 Americans annually; 10–30% die within 30 days of diagnosis, and 20–25% of PE cases are sudden death.

Deep vein thrombosis (DVT) is the result of around two-thirds of venous thromboembolism (VTE) cases, while PE is the primary symptom of the remaining one-third. Although DVT is usually associated with hospitalized patients, over two-thirds of cases actually occur in outpatient settings. Heredity, advanced age, hypercoagulable diseases (like cancer), and temporary situations (like medication, bed rest, hospitalization, travel, and trauma) are among the factors that raise the risk of blood clots. When many variables interact and may have a cumulative effect, the likelihood of mortality may increase. Despite intensive attempts to identify and quantify DVT dangers, a substantial fraction of DVT cases up to 20% are classified as idiopathic, meaning no discernible risk factor has been identified. Because of this, DVT is an extremely difficult disease to predict and prevent.

A new interventional technique called catheter-directed thrombolysis (CDT) involves administering fibrinolytic drugs directly into thrombi using catheter systems in order to dissolve them more quickly.

Treatment with Minimally Invasive Endovascular Catheter-Directed Thrombolysis (CDT)

The potential for CDT to improve patient quality of life and decrease risk of PTS is high since it restores venous patency while maintaining valve function. Nevertheless, CDT needs specialised infrastructure and knowledge and is linked to an increased risk of bleeding, which restricts its normal implementation. In addition to anticoagulation, catheter-directed thrombolysis (CDT) is an endovascular minimally invasive therapy for acute DVT. Early recanalisation of DVT, made possible by CDT's ability to prevent persistent thrombosis from damaging the deep vein valve, lowers the risk of post-thrombotic syndrome (PTS)[1]. This article provides a concise overview of CDT, including its uses, potential side effects, and how the procedure is performed. Compared to systemic thrombolysis, in which the drug is given systemically throughout the body, CDT tries to lessen the likelihood of bleeding problems by concentrating on the clot specifically [2].

CDT intervention involves assessing the costs and risks against the benefits of minimising PTS and reoccurring DVT. Due to its long-term benefits, CDT is best for patients with IFDVT and other severe thromboses at high risk for recurrence and/or PTS, as well as those with a long life expectancy and minimal comorbidities. Three medical associations advocate CDT for DVT.All CDT recommendations advocate using it with anticoagulation. The American College of Chest Physicians (CHEST) warns that there is inadequate study to assess CDT's hazards and benefits, even if most of its benefits are likely to be acknowledged. CHEST suggests anticoagulant therapy alone for acute proximal leg DVT, not CDT. It stresses that patients who value avoiding PTS over procedure and bleeding expenses are more likely to select CDT over anticoagulation, supporting this notion. The AHA recommends CDT as the initial therapy for acute IFDVT (<21 days after symptom onset), limb-threatening impairment, rapid thrombus extension, or symptomatic progression despite anticoagulation. SIR implies that CDT may help a subgroup of acute femoropopliteal DVT patients, but the treatment threshold should be greater than for IFDVT. Internal bleeding, stroke within 3 months, neurosurgery, and head trauma are contraindications. Cardiovascular resuscitation, gastrointestinal haemorrhage, brain tumour, thrombocytopenia, uncontrolled hypertension (systolic blood pressure >180 mmHg), or suspicion of an infected thrombus should prevent this procedure.[3]

Benefits

- **Reduced Bleeding Risk:** Thrombolytic drugs are delivered directly to the clot during CDT, as opposed to being administered systemically. This may reduce the risk of bleeding problems and minimize exposure to other areas of the body.
- **Targeted Therapy:** Rapid clot breakdown and better results may be possible because to CDT's pinpoint medicine delivery to the clot.
- **Potential for Improved Long-Term Outcomes:** Because CDT protects venous valves and reduces clot load, it may aid DVT patients in avoiding PTS.

Risks

- **Bleeding:** Intracranial hemorrhage is one of the possible side effects of the usual risk of bleeding associated with thrombolytic treatment.
- **Infection:** There is always the chance of infection, whether it is at the puncture site or inside the blood artery, when a catheter is inserted.

- **Other Complications:** Potential side effects include contrast-related allergies, vascular injury, and, extremely rarely, the clot material dislodging and spreading to other organs [4-7].

Relevant Trends in DVT Treatment

Inadequacy or obstruction of the deep venous system is the primary cause of post-thrombotic syndrome (PTS). Despite optimal therapy, only 30% of iliac veins recanalise after iliofemoral deep vein thrombosis. Fifteen percent of individuals acquire venous claudication and forty-four percent have venous DVT within five years after having iliofemoral DVT. According to Vedantham et al., the risk of PTS is significantly heightened when obstruction and reflux coexist, rather than when each factor is present independently. Early clot lysis correlates with an increased probability of valve function preservation, as demonstrated by Meissner et al. Despite promising findings about catheter-directed thrombolysis (CDT), much of the existing research is derived from case series. Randomised treatment research also produce limited data. Enden et al. presented the initial long-term results of a prospective randomised research endorsing catheter-directed thrombolysis for deep vein thrombosis (DVT)[8].

Anticoagulants are crucial for reducing the risk of pulmonary embolism (PE), a potentially fatal outcome of deep vein thrombosis (DVT), and for preventing the recurrence of DVT.

Anticoagulation is Necessary

- **Prevents clot growth and recurrence:** In addition to preventing further clotting in the affected veins, anticoagulants inhibit current clots from becoming bigger.
- **Reduces risk of pulmonary embolism (PE):** The risk of pulmonary embolism (PE) increases when a deep vein thrombosis (DVT) ruptures and flows to the lungs. The danger of this potentially fatal consequence is greatly reduced with anticoagulation.
- **Prevents post-thrombotic syndrome:** Chronic pain, swelling, and skin changes in the afflicted leg are symptoms of post-thrombotic syndrome; however, the chance of developing this illness can be reduced with long-term anticoagulation [9].

Types of Anticoagulants

- **Direct Oral Anticoagulants (DOACs):** Rivaroxaban, apixaban, dabigatran, and edoxaban are examples of these often prescribed medications. Advantages over earlier choices include fast action, oral administration, and typically acceptable effectiveness and safety.
- **Vitamin K Antagonists (VKAs):** The most famous VKA is warfarin.It necessitates dietary changes and routine monitoring of blood clotting times (INR).
- **Low-Molecular-Weight Heparin (LMWH):** Notable examples include enoxaparin and dalteparin. Injections of these are the norm and are reserved for certain medical scenarios, such as pregnancy or the presence of cancer.
- **Unfractionated Heparin (UFH):** This is the gold standard for starting treatment, particularly for inpatients, and it could be the best option for some conditions, such as thrombolytic therapy.

Duration of Anticoagulation

- **Initial Treatment:** Anticoagulation treatment usually lasts between three and six months.
- **Extended or Indefinite Treatment:** Patients with high risk factors, those with spontaneous deep vein thrombosis (DVT) or perforated embolism(PE), and other situations may necessitate prolonged or permanent anticoagulation [10].
- **Individualized Decisions:** Each patient's risk factors, clot site and size, and general health condition are considered when deciding how long anticoagulation should last.

Objectives of the Study

- To study on Relevant trends in DVT treatment.
- To evaluate the safety profile of catheter-directed thrombolysis (CDT) compared to anticoagulation alone.
- To assess the healthcare resource utilization and economic impact of CDT versus anticoagulation therapy, including length of hospital stay and treatment costs.

- Compare patient outcomes between CDT and anticoagulation therapy: Examine differences in recurrence rates, complication profiles (e.g., bleeding, pulmonary embolism), and overall quality of life after treatment.

Methods

Study Design

Patients diagnosed with deep vein thrombosis (DVT) were treated at RVS Hospital between 2024 oct. to 2025 oct, where the subjects of this retrospective, single-center research. The Ravuri Venkata Swamy Institute of Medical Sciences and Research (RVIMSR), the principal medical facility in Chittoor, Andhra Pradesh, received approval for the study from its Human Research Ethics Committee. In all, 114 patients met the inclusion criteria for the trial; 72 received ACA treatment and 42 received CDT. The study included patients with proximal deep vein thrombosis (DVT) in the lower limbs who were at least 18 years old and had data from at least 30 days of follow-up. Included were patients whose overall health was stable, who posed little danger of bleeding, and who had a predicted survival time of one year or more. The research included both cases of DVT that were triggered and those that were not.In the main analysis, the aetiology of DVT was not utilised as a stratification variable. Excluded from the study were patients who were pregnant or in the postpartum period, those who were actively bleeding or at high risk of severe bleeding, those who had undergone lower limb vascular surgery before, and those who had previously had thrombolytic treatment for pulmonary embolism [11].

Outcomes

The study focused on 30-day post-surgery mortality. Secondary objectives were hospital stay, pulmonary embolism, major and minor haemorrhage, and critical care unit stay. Even though PTS was neither a main or secondary endpoint, clinical presentation and symptoms were used to describe it during follow-up. The study's retrospective nature hindered regular use of a validated grading system like the Villalta scale. The Villalta scale creates a severity score for PTS that is widely used and recognised by integrating patient symptoms with objective clinical data. Instead, frequent clinical tests focused on venous stasis, skin discolouration, oedema, and limb pain. ISTH criteria classified major bleeding as deadly, symptomatic cerebral haemorrhage, surgical intervention, transfusion of two units of blood, or haemodynamic instability. Medically relevant non-major haemorrhage was overt bleeding that did not meet major criteria but required care [12].

Treatment Protocol

Patients first treated with intravenous unfractionated heparin (UFH) were categorised as being in the anticoagulation (AC) group in this research.To keep the activated partial thromboplastin time (aPTT) within the usual range of 1.5-2.5 times, the heparin dose was modified. We used serial aPTT measurements to guide all dosage adjustments as anti-Xa monitoring was not available at our institution.Clinical evaluation and coagulation profiles were used to thoroughly treat any baseline extended aPTT.All patients were given full-dose oral anticoagulant for at least three months after the first intravenous treatment. The entire period of anticoagulation was decided for each patient according to their specific risk factors for thromboembolism.

Those who were part of the catheter-directed thrombolysis (CDT) study had venous access and catheter insertion guided by ultrasonography. Because of its anatomical appropriateness, simplicity of puncture with ultrasound guidance, and shorter access path, the popliteal vein was chosen as the site of access. Anatomical constraints or unsuccessful efforts made access via the popliteal vein impractical; the femoral vein or the tiny saphenous vein (vena saphena parva) were used as alternatives. Catheterisation through the small saphenous vein was used as a backup plan in cases when the popliteal vein was unavailable or too deep.

Ultrasound is the procedure involved positioning the patient on their back and inserting a 5F catheter into the popliteal vein while monitoring their progress using real-time ultrasonography. The same infusion catheter was used to catheterise thrombi affecting the iliocaval junction via the femoral vein.

The German pharmaceutical company Boehringer Ingelheim used alteplase (ACTILYSE®) for the thrombolysis procedure. The patient was given a 20 mg intravenous bolus of alteplase and then an infusion of 0.5-1 mg hourly for up to 24 hours. The infusion was terminated after 24 hours to minimise bleeding risks, regardless of the amount to which the thrombus had resolved.Patients undergoing thrombolysis were subject to round-the-clock evaluation of haemodynamic state and bleeding parameters

in the critical care unit. Following thrombolysis, the patient's laboratory tests, such as serum creatinine, INR, PTT, and complete blood count (CBC), were closely examined.

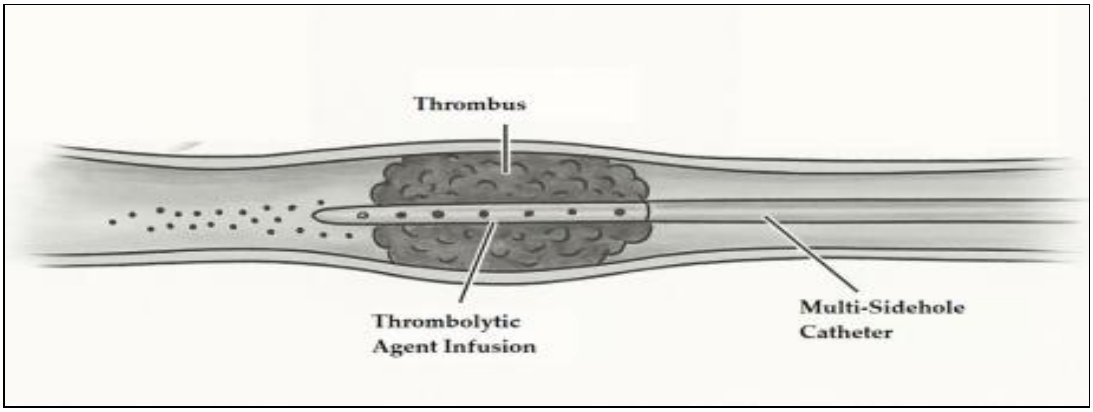

Figure 1: Showing the schematic of CDT thrombolytic agent can be delivered locally by inserting the multi-sidehole catheter into the thrombosed section of the deep vein.

All patients undergoing CDT were switched to full-dose oral anticoagulation medication after the thrombolysis process. This treatment was maintained for at least three months, with the length varied according on each patient's risk factors for thromboembolic complications.Patients were closely observed for any indications of bleeding for a minimum of 96 hours following the surgery.

Regular outpatient follow-ups were organised for patients after discharge in order to evaluate treatment results and keep an eye out for problems. One month following release, there was a first follow-up appointment, and then there were appointments at 3,6, and 12 months.At these checkups, we looked for symptoms of post-thrombotic syndrome, sequelae from deep vein thrombosis, and whether or not the patient's symptoms had resolved. In order to evaluate venous recanalisation, identify recurrent thrombosis, and track the patency of the impacted segments, duplex doppler ultrasonography was conducted at every appointment.

Doppler ultrasonography indicated near-complete recanalisation and restoration of venous blood flow in the afflicted segment, which was used to define the thrombus resolution rate as a reduction in the thrombus load of 90% or more.We stopped administering anticoagulant medication after we reached this level of clearance, which was verified by several ultrasounds. In order to identify any new thrombotic events during follow-up, evaluate thrombus clearance, and keep an eye on venous flow dynamics, Doppler ultrasonography was used as a dependable and non-invasive imaging method. Moreover, for the duration of the follow-up, we reinforced and evaluated the patients' compliance with anticoagulant treatment.In order to maximise the effectiveness and safety of therapy, this protocol provided a methodical way to evaluating results, complications, and long-term recovery in both groups, and it also made sure that patients had the right anticoagulation and were well monitored.

Statistical Analysis

we used statistical analysis to compare ac and cdt treatment groups on several outcome markers. we quantified data's central tendency and variability using the mean ± standard deviation (sd) for continuous variables. to compare these factors, we employed the t-test, which is robust when comparing means across unrelated groups.this study tested for normal distribution using the shapiro-wilk test and homogeneity of variance using levene's test. the t-test assumes equal group variances [13].the incidence and percentages of problems such gastrointestinal bleeding and pe were shown. the categorical variables were compared using fisher's exact chi-squared. use the chi-squared test to compare two category variables. fisher's exact test is more accurate for cell frequencies under 5.this supports statistical reasoning, especially with sparse contingency table data or small samples. for all statistical tests with p-values < 0.05, strong evidence rejected the null hypothesis that groups are similar [14-17].

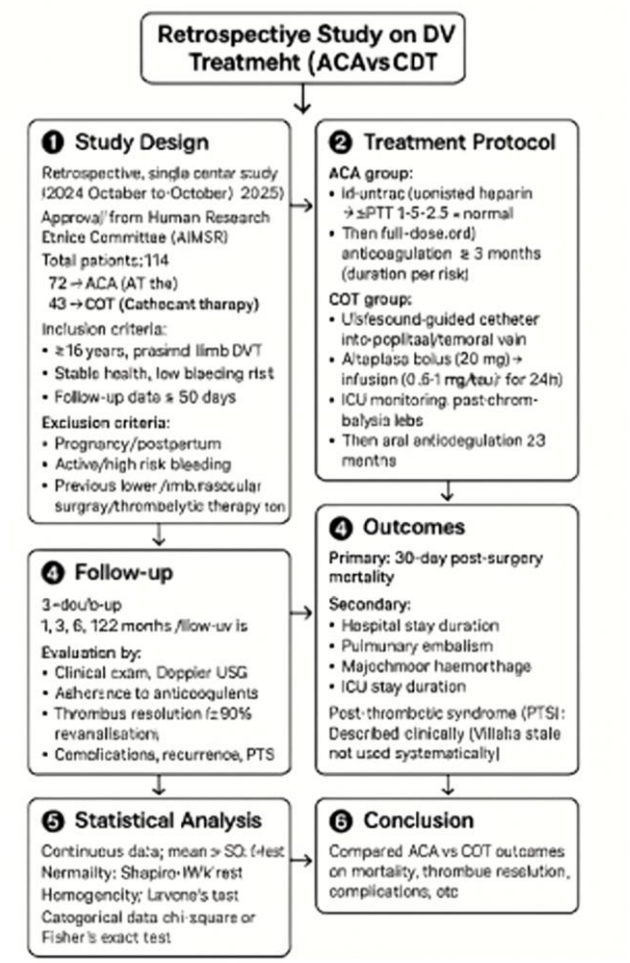

Figure 2: Flow Chart of Retrospective Study on DV Treatment ACA Vs CVT

Results

The research comprised 114 patients with deep vein thrombosis (DVT). Out of these, 72 were administered AC, whereas 42 were given Catheter directed thrombolysis (CDT). It was possible to compare the treatment methods fairly since the two groups' baseline demographics were comparable (Table 1).

Table 1: Baseline Personality of the Patients

Characteristics	AC (n=72)	CDT (n=42)	p-Value
Age (Year, Mean)	57.2	54.3	0.15
Male	25 (34.72%)	12 (28.57%)	0.52
Diabetes Mellitus	10 (13.88%)	5 (11.90%)	0.75
BMI > 30	5 (6.9%)	6 (14.28%)	0.20
Hypertension	5 (6.9%)	4 (9.51%)	0.72
Cerebrovascular Accident	10 (13.88%)	1 (2.38%)	0.05
Smoking	7 (9.7%)	6 (14.28%)	0.42
Hyperlipidemia	3 (4.1%)	4 (9.51%)	0.25
Malignancy	2 (2.78%)	2 (4.76%)	0.61
Previous DVT	3 (4.14%)	1 (2.38%)	0.66
Thrombophilia	2 (2.78%)	1 (2.38%)	0.86

The baseline characteristics of the two groups, AC (n = 72) and CDT (n = 42), were generally comparable. Although the AC group had a little greater mean age (57.2 years) than the CDT group (54.3 years), this difference was not statistically significant (p = 0.15).Both groups had similar male patient proportions (34.72% vs 28.57%; p = 0.52). Diabetes, hypertension, hyperlipidaemia, malignancy, DVT, thrombophilia, and smoking status did not substantially vary across groups (all p > 0.05). Although a higher percentage of patients in the CDT group had a BMI greater than 30 (14.28% vs 6.9%), this difference did not reach statistical significance (p = 0.20). Notably, a history of cerebrovascular accident was more common in the AC group (13.88% vs 2.38%), showing a trend toward significance (p = 0.05). [18].

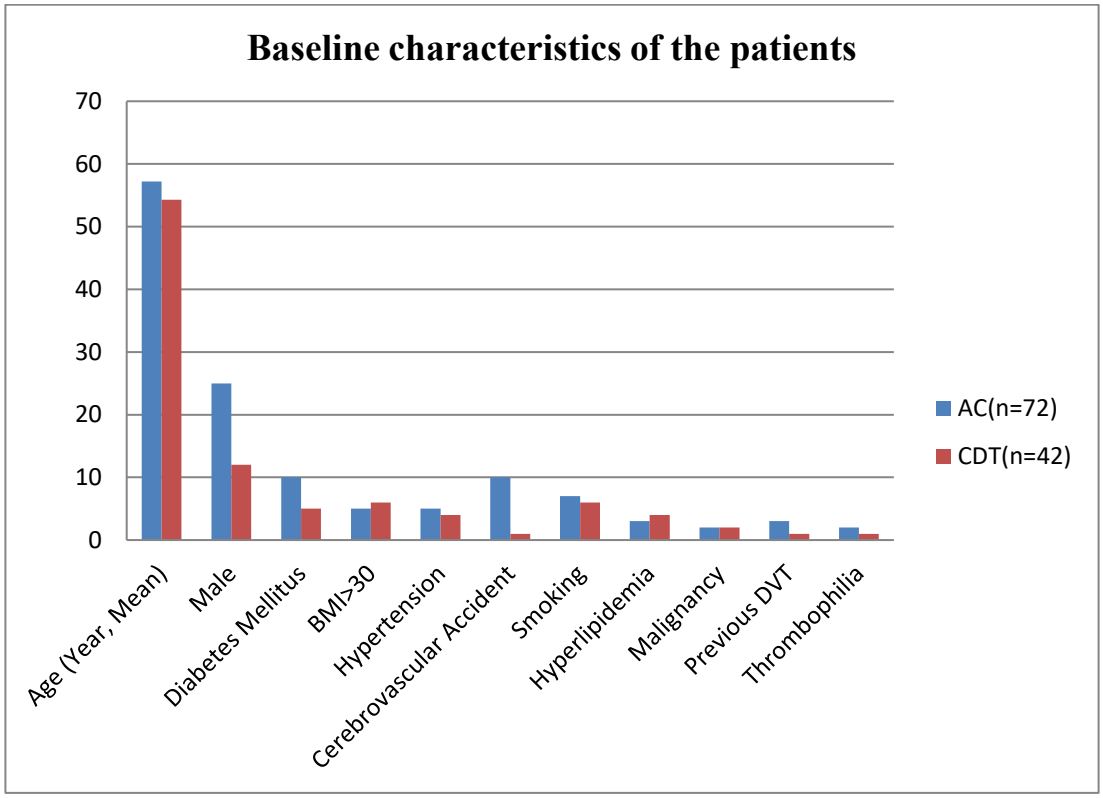

Figure 3: Baseline characteristics of the patients

Table 2: Results of AC or CDT Groups for Patients

Effect	AC (n=72)	CDT (n=42)	p-Value
Pulmonary Embolism	35 (48.61%)	10 (23.80%)	0.004
Gastrointestinal Bleed	10 (13.88%)	13 (30.95%)	0.04
Intracranial Hemorrhage	12 (16.66%)	5 (11.90%)	0.46
Hematoma	13 (18.05%)	12 (28.57%)	0.19
Death	2 (2.77%)	2 (4.76%)	0.62

Data is shown as n (%) or mean ± standard deviation. AC: anticoagulation alone; CDT: catheter-directed thrombolysis.

Pulmonary embolism was more common in the AC group (48.61%) than in the CDT group (23.80%), a difference that reached statistical significance (p = 0.004) when comparing the two groups' clinical outcomes. There was a statistically significant difference in the frequency of gastrointestinal bleeding between the CDT group (30.95%) and the AC group (13.88%) (p = 0.04). In terms of cerebral haemorrhage (16.66% vs 11.90%; p = 0.46), haematoma (18.05% vs 28.57%; p = 0.19), and mortality (2.77% in both groups; p = 0.62), however, no significant differences were found between the two groups. [19].

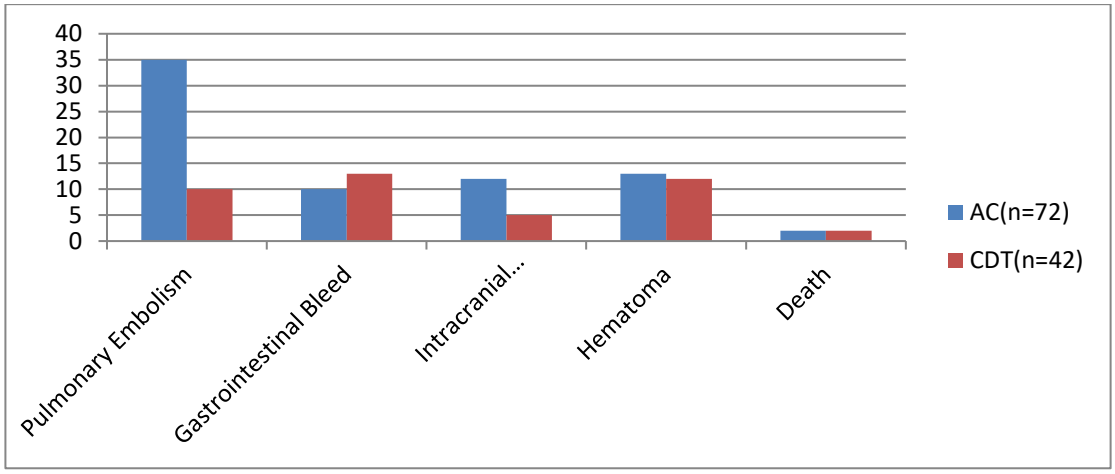

Figure 4: Results of AC or CDT groups for patients

Table 3: Thrombus Localization

Lesion	AC (n=72)	CDT (n=42)	p-Value
Inferior Vena Cava	25 (34.72%)	14 (33.33%)	0.87
Iliac Vein	14 (19.44%)	5 (11.90%)	0.30
Femoral Vein	10 (13.88%)	5 (11.90%)	0.75
Popliteal Vein	16 (22.22%)	9 (21.42%)	0.92
Calf Vein	7 (9.72%)	9 (21.42%)	0.08

Data is shown as n (%) or mean ± standard deviation. AC: anticoagulation alone; CDT: catheter-directed thrombolysis. The AC and CDT groups did not differ significantly with respect to the distribution of thrombus sites. Lesions affecting the inferior vena cava were 34.72% in AC and 33.33% in CDT (p = 0.87). The AC group was more likely to have iliac vein involvement (19.44%) than the CDT group (11.90%), but there was no statistically significant difference. In a similar vein, there was no significant difference in femoral vein involvement (p=0.75) or popliteal vein involvement (p=0.92) between the groups. There was a tendency towards significance (p=0.08), as the CDT group had a higher incidence of calf vein thrombosis (21.42% vs 9.72%). The two treatment groups showed similar anatomical distributions of thrombi [20].

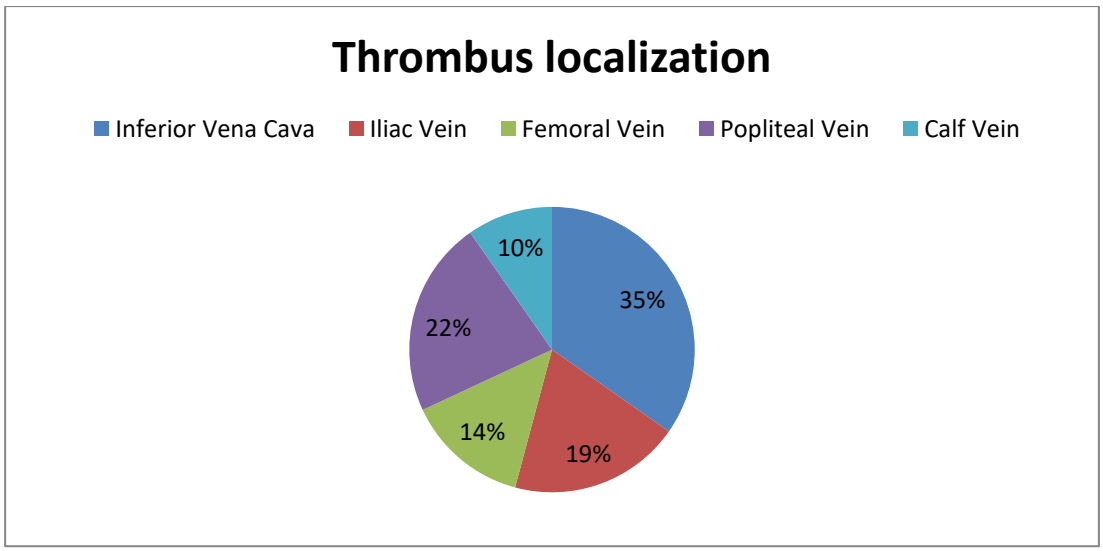

Figure 5: Thrombus localization

Table 4: Segment Thrombus Clearance Rate

Lesion	AC (n=72)	CDT (n=42)	IR (95% CI)
Inferior Vena Cava	30 (41.66%)	14 (33.33%)	0.80 (0.42–1.51)
Iliac Vein	14 (19.44%)	8 (19.04%)	0.98 (0.41–2.34)
Femoral Vein	15 (20.83%)	5 (11.90%)	0.57 (0.21–1.57)
Popliteal Vein	10 (13.88%)	9 (21.42%)	1.54 (0.63–3.80)
Calf Vein	3 (4.16%)	6 (14.28%)	3.43 (0.86–13.71)

Both the Anticoagulation (AC) and Catheter-Directed Thrombolysis (CDT) groups show significant variations in segmental efficacy when analysing the incidence rate (IR) of thrombus clearance by lesion location. With an IR of 0.80 (95% CI: 0.42-1.51), CDT demonstrated a 20% decrease in clearance probability in the Inferior Vena Cava compared to AC; nevertheless, the confidence interval surpasses 1, indicating statistical insignificance. Likewise, the CDT group had decreased clearance in the femoral vein, with an IR of 0.57 (ranging from 0.21 to 1.57). As far as the Iliac Vein was concerned, the two treatments were almost equally successful, with an IR of 0.98 (0.41-2.34).

Contrarily, in the more distal regions, CDT was linked to increased clearance. In the Popliteal Vein, the IR for CDT was 1.54 (0.63-3.80), which indicates a 54% higher clearance rate; in the Calf Vein, the highest IR was 3.43 (0.86-13.71), which indicates a clearance that is more than three times greater in the CDT group; however, the lack of statistical precision is indicated by the wide confidence intervals. While anticoagulation is still somewhat efficient in more proximal segments like the femoral and inferior vena cava, our results imply that CDT may provide better thrombus clearance in distant veins (popliteal and calf). [21].

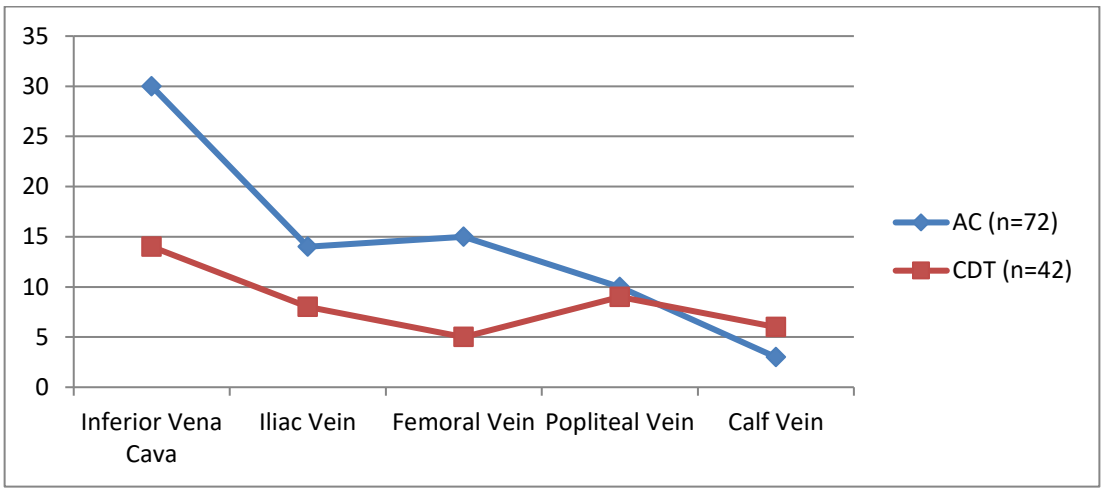

Figure 6: Thrombus Clearance Rate by Segment

Table 5: Use of resources by patients in propensity-matched groups receiving CDT or anticoagulation

	CDT Group (n=42)	Anticoagulation Group (n=72)	*P* Value
Length of hospital stay, Days			<0.001
Mean±SD	8.1±6.4	6.9±7.2	
25th %	4.0	3.0	
50th %	7.0	5.0	
75th %	10.0	8.0	
Charges, $			<0.001
Mean±SD	103. 164±91. 494	50 .689±69 .960	
25th %	55.942	16.137	
50th %	85.866	30.282	
75th %	12.4689	55.605	

CDT Indicates Catheter-Directed Thrombolysis

Statistically significant differences (P < 0.001) were seen in both the length of hospital stay (n=42) and associated expenses (n=72) between patients in the CDT group and the Anticoagulation group. In the CDT group, patients stayed in the hospital for an average of 8.1 ± 6.4 days, while in the Anticoagulation group, it was 6.9 ± 7.2 days. There was a clear trend between the 25th and 75th percentiles, showing that the CDT group had a longer median (50th percentile) stay (7.0 days) than the Anticoagulation group (5.0 days).

Likewise, the CDT group incurred much higher hospital expenditures, with an average bill of $103,164 ± 91,494 compared to the Anticoagulation group's $50,689 ± 69,960. Again, the CDT group had much greater expenses across the board, with a median charge of $85,866 compared to $30,282 in the anticoagulation group. Contrasted with anticoagulant medication, our results indicate that CDT is linked to lengthier hospital stays and more healthcare expenses.

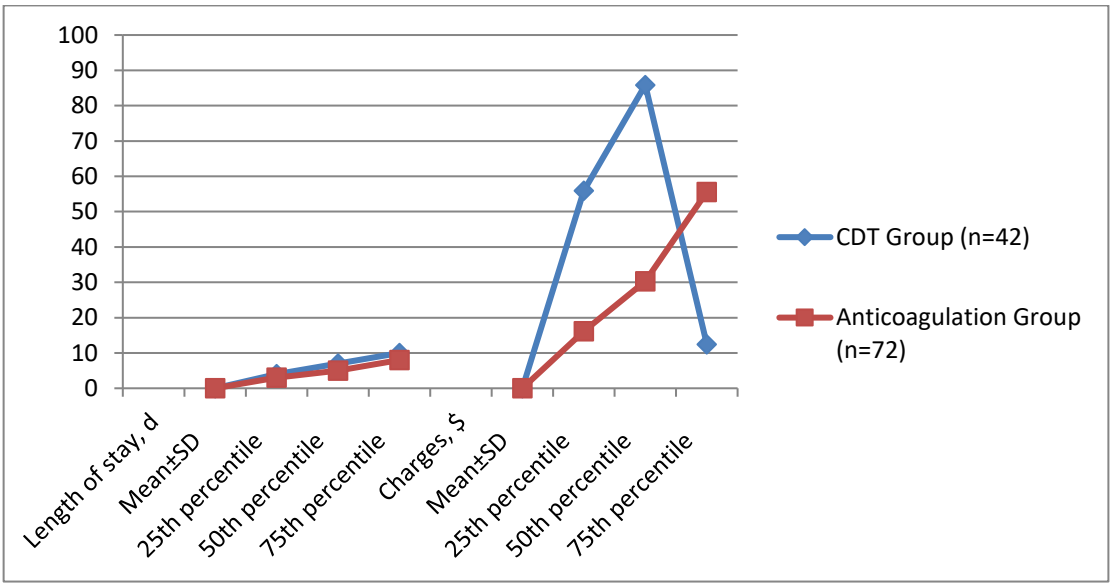

Figure 7: Use of Resources by Patients in Propensity-Matched Groups Receiving CDT or Anticoagulation

Discussion

For years, researchers have examined the efficacy of mechanical thrombectomy, traditional anticoagulants, and interventional treatments like CDT in treating deep vein thrombosis. Combining our data with the current literature will help compare approaches' efficacy and complications. CDT reduced PTS and improved target vessel maintenance in the CAVENT study. Thrombolytic medicines may cause severe bleeding, limiting CDT use. CDT improved acute thrombosis symptoms, however ATTRACT showed no long-term effect on PTS. CDT should be used on carefully selected individuals, according to the findings. Lu et al. observed that CDT enhanced iliofemoral vein patency and decreased severe PTS compared to anticoagulation alone in a thorough analysis of 10 clinical investigations. The studies were too variable to determine the advantages of avoiding mild or complete PTS. Our population's safety profile and meta-analysis showed a high CDT group bleeding and pulmonary embolism risk. Our CDT patients had greater thrombus clearance and symptom alleviation, supporting the hypothesis that CDT may be effective in select patient groups despite the risks. Mechanical thrombectomy for DVT is becoming more prevalent. In the defiance study, mechanical thrombectomy cleared clots faster than anticoagulant medication alone, but there was no difference in long-term venous patency or PTS rates. However, multiple studies have demonstrated that CDT improves mechanical thrombectomy.[22]

Pharmacochemical thrombolysis, especially endovenous, reduces clot clearance time and bleeding risk by decreasing systemic thrombolytic dose, according to Makedonov et al. [23] The procedure preserves venous function throughout time, especially in young, active people. The study found lower PTS rates than conventional anticoagulants. Based on these discoveries, mechanical

procedures may make CDT more efficient. Ultrasound-guided interventional DVT therapies are essential. Ultrasound-guided therapy may preserve venous patency better than conventional methods. Early intervention may reduce PTS, according to study. Thukral et al.'s study on deep vein thrombosis (DVT) care stressed the necessity of early endovenous treatment to enhance patients' quality of life and reduce symptoms. The study is relevant since it reduces health costs and hospitalisations. These treatments are low-risk and may be best performed in the iliofemoral section. These findings suggest that invasive treatments are clinically and economically viable. The literature suggests that patients with extensive proximal thrombosis or prior VTE should be carefully selected for interventional therapies like CDT and mechanical thrombectomy and their long-term effects studied [24-27]. Compliant patients and long-term anticoagulant use can minimise DVT recurrence. Dicks et al. found that improved imaging can customise interventional therapy, improving outcomes and reducing complications. The article states that MR venography and ultrasound are crucial to patient selection and can detect subclinical pulmonary embolism and other issues early in deep vein thrombosis (DVT). It's crucial to optimise decision-making support as well as treatment types. These differences in opinion show that CDT isn't always required for DVT patients, although it could help those who have significant symptoms, a low risk of bleeding, and a lot of iliofemoral thrombosis. The current guidelines from the ACCP and SVS stress the importance of carefully selecting patients, weighing the possible advantages of thrombus removal against the higher risk of bleeding.

The technical aspect and the operator's skill are additional crucial considerations. There is a great deal of variation in CDT success rates and complication profiles between institutions, imaging modalities, and catheter systems. New clot clearance and infusion time technologies, such as mechanical thrombectomy devices and ultrasound-assisted CDT, have the potential to lessen the risk of bleeding problems caused by extended thrombolytic infusions. Additionally, our research highlights the difficulties that real-world situations with limited resources face. The anticoagulation accuracy may have been compromised due to the use of aPTT to guide heparin dose in the absence of anti-Xa monitoring. A number of facilities lack the necessary resources for critical care, interventional radiologists with the necessary training, and specialised equipment to do CDT, which is especially true in countries with low or medium incomes.

Regardless of the initial treatment strategy, it is vital that patients adhere to post-procedural anticoagulation and follow-up observation. If the precautions taken to prevent recurrent deep vein thrombosis (DVT), insufficient recanalisation, or residual thrombus are not sufficient, the advantages of thrombolysis may be diminished. Based on our results and the current data, CDT should not be used as a first-line treatment for all cases of deep vein thrombosis (DVT), but it might be useful for a subset of patients who have substantial proximal DVT and are at high risk for percutaneous transfusion syndrome (PTS). If we want to know which subgroups get the most benefits from CDT and how to improve clinical practice recommendations, we need more randomised studies that include many centres, strict patient selection criteria, standardised procedures, and extended follow-up. Another consideration is DVT's global health effect[18]. A management plan should consider the patient's profile, clinical status, and risk factors. Mechanical thrombectomy, CDT, and anticoagulants may aid certain patients. Larger patient groups must engage in long-term follow-up studies to determine the efficacy and long-term impact of these treatments [28-34].

Conclusion

Preventing valvular damage and lowering long-term sequela of post-thrombotic syndrome (PTS), CDT improves quality of life following deep vein thrombosis (DVT). Compared with anticoagulation alone, CDT further lowers the incidence of recurrent DVT. It is possible that CDT may be an economical supplement to conventional anticoagulation in properly chosen individuals. Beneficial outcomes are more probable for patients with long life expectancy and acute IFDVT. This is why CDT is suggested as an initial line of adjunctive treatment for acute IFDVT by the SIR and the AHA. Bleeding is the most common side effect of CDT, and it usually only happens at the venous access site. To reduce patient risk, CDT therapy must be accompanied by close clinical monitoring. Although it is extremely rare (<1%), intracranial haemorrhage can be a fatal consequence. When compared to anticoagulation alone, there is no evidence to imply an increased risk of PE following CDT. In order to confirm the usefulness of CDT and evaluate its complication rate, further prospective randomised studies are required. The best way to treat deep vein thrombosis (DVT) depends on the patient's unique risk factors and health status. While some patients may benefit from interventional procedures, it doesn't mean they're a good fit for everyone.

Hence, the effectiveness of treatment strategies can be better understood through future large-scale and long-term investigations. Our research adds to the body of knowledge and highlights areas that will require future studies with bigger patient groups to address.

Limitations

While this large-scale prospective cohort research compares anticoagulation (AC) with catheter-directed thrombolysis (CDT) for deep vein thrombosis (DVT), it does have several limitations that should be considered. To begin with, despite efforts to ensure that participants had similar baseline characteristics, the study's lack of randomisation raises concerns about selection bias and residual confounding. Second, the outcome consistency in the CDT group might be impacted by variances in operator skill, thrombolytic drugs, dosing guidelines, and adjunctive treatments, which were not standardised across centres. Thirdly, subgroup analyses are limited because significant subgroups, such patients with underlying thrombophilia or substantial iliofemoral thrombosis, are under-represented, even though the cohort size is rather high. Finally, when considering the pros and cons of invasive procedures like CDT, it is crucial to take into account quality-of-life and complete patient-reported outcomes; they were not included in the study.

Future Directions & Recommendations

To further support these results, future studies comparing CDT with conventional anticoagulation for various subtypes of deep vein thrombosis should employ well-designed multicenter randomised controlled trials. The real prevalence of PTS, rates of recurrence, and chronic venous problems can only be determined with longer durations of follow-up. To further reduce operator-dependent variability and find the best patient selection criteria for maximising benefit while minimising danger, future research should look at standardised CDT techniques. To better understand CDT's function in everyday clinical practice, it is important to include patient-reported outcomes, functional status, and cost-effectiveness evaluations. Furthermore, individualised approaches to DVT care can be informed by real-world data and registries that include a wide range of patients, which can supplement randomised studies.

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