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Upper Extremity Deep Vein Thrombosis Treated with Mechanical Thrombectomy: A Single-Center Retrospective Analysis

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Abstract

Purpose The incidence of upper extremity deep vein thrombosis (UEDVT) is rising, and few studies have assessed interventional treatment strategies. Here, we aim to evaluate outcomes following standalone mechanical thrombectomy for UEDVT.

Methods Retrospective chart review was conducted for all patients who underwent standalone mechanical thrombectomy for UEDVT between October 2019 and August 2023. Outcomes assessed included technical success (≥75% thrombus removal), intraprocedural adverse events, postprocedural hospital stay, and follow-up free from death, pulmonary embolism, and rethrombosis.

Results Mechanical thrombectomy was utilized in 14 patients during the study period. The median age was 44.0 years (interquartile range: 33.5, 57.0), and seven of the patients (50.0%) were female. All procedures were technically successful and completed in a single session with no serious adverse events. The median postprocedural stay was 2 days. At a median follow-up of 88 days, there were no mortalities, and 71.4% of patients ($n = 10$) were free of rethrombosis and pulmonary embolism.

Conclusion This analysis suggests that mechanical thrombectomy provides effective thrombus removal and can be safely completed in patients with UEDVT.

Keywords

- deep vein thrombosis
- mechanical thrombectomy
- Paget–Schroetter's syndrome

Introduction

Upper extremity deep vein thrombosis (UEDVT) has an estimated annual incidence of 1 per 10,000 people and accounts for up to 10% of all deep vein thrombosis (DVT) cases.[1–3] Recent increases in the use of central venous catheters, peripherally inserted central catheters, and pacemakers have led to a steady rise in the incidence of UEDVT.[3,4] Indwelling central venous catheter use has been associated with a 7-fold to 14-fold increase in the likelihood of developing a secondary or provoked UEDVT, constituting the majority of UEDVT cases.[5,6] Although primary UEDVT or Paget–Schroetter's syndrome (PSS) is less common, these cases can be more severe and may require decompression surgery to alleviate the underlying anatomical cause of thrombosis.[1,3] Complications of UEDVT are similar to those observed with lower extremity DVT and include pulmonary embolism, rethrombosis, and post-thrombotic syndrome.[7,8]

While symptoms of UEDVT can often be effectively managed with anticoagulation over time,[9] rapid restoration of symptoms is preferred. The CHEST guidelines suggest considering catheter-directed thrombolysis for patients with severe symptoms, thrombus involving most of the subclavian and axillary veins, symptoms <14 days, good functional status, life expectancy ≥1 year, and low bleeding risk.[9] Unfortunately, there are few studies assessing endovascular treatments in UEDVT.

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Retrospective studies have reported effective restoration of patency in UEDVT patients treated with catheter-directed thrombolysis, although its use is associated with increased bleeding risks.[9–12] Positive outcomes have been reported with aspiration thrombectomy for the treatment of primary UEDVT.[2,13] To our knowledge, no study has assessed standalone mechanical thrombectomy techniques for UEDVT, which we aimed to address with this study.

Materials and Methods

Research Ethics Standards Compliance

This study obtained Institutional Review Board approval under the exempt process. For this type of study, formal research ethics committee review, informed consent, or consent for publication are not required. The research was performed according to the Declaration of Helsinki principles.

Study Design

This is a single-center retrospective chart review of patients who underwent mechanical thrombectomy for the treatment of UEDVT. All patients who received treatment with the ClotTriever system (Inari Medical, Irvine, California, United States) for UEDVT between October 3, 2019, and August 7, 2023, were included, irrespective of UEDVT etiology, age, or health status.

Study Outcomes

The primary outcome was technical success, defined as ≥75% of thrombus removal. Technical success was determined by an interventional radiologist who reviewed the preprocedural and postprocedural venograms for each patient. Intraprocedural adverse events are reported. Secondary outcomes included the ability to complete the procedure in a single session, the length of postprocedural hospital stay, and the proportion of patients who remained free from death, pulmonary embolism, and rethrombosis during follow-up. The follow-up period was defined as the duration between the procedure date and the date of the last follow-up appointment.

Study Device and Procedure

The ClotTriever system is a single-use, over-the-wire system comprising a sheath and thrombectomy catheter (►**Fig. 1**). This device is U.S. Food and Drug Administration cleared and CE marked for treating lower extremity DVT.[14,15]

Venous access was obtained with a guidewire. Basilic vein access was preferred given the theoretical risk of injury to the adjacent nerve or artery with brachial vein access. After the initial venogram, dilation of the venotomy site was performed, followed by the introduction of the device sheath and deployment of the mesh funnel.

After the introduction of the ClotTriever catheter via the sheath, the coring element and collection bag were deployed. The catheter was retracted through the thrombosed venous segment into the funnel of the sheath, and the plunger was then used to collapse the coring element and collection bag prior to the removal of the catheter with the captured thrombus. Additional thrombectomy passes were repeated until the thrombus was removed.

Statistical Methods

Baseline and procedural characteristics, periprocedural outcomes, and outcomes through follow-up are expressed as median values with interquartile range (IQR) or number of observations with proportion of the total population or

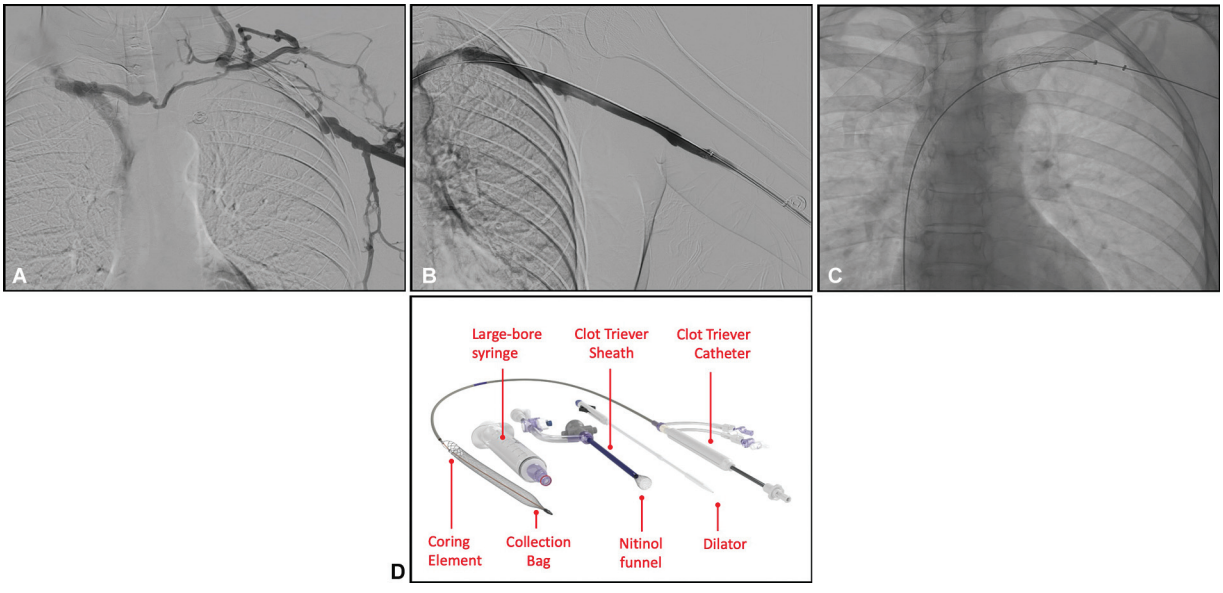

Fig. 1 A 40-year-old woman presenting to the emergency room with swelling, numbness, and discoloration of the left upper extremity following septoplasty and left tympanostomy tube placement. (**A**) Preprocedural venographic fluoroscopy demonstrating left upper extremity brachial vein deep venous thrombosis extending into the left jugular vein. (**B**) Postprocedural venographic imaging demonstrating resolution of thrombus. (**C**) Image of a deployed device within the upper extremity. (**D**) Depiction of components of the ClotTriever system (Copyright of Inari Medical, Irvine, California, United States).

procedure number. Data were analyzed using Microsoft Excel for Microsoft 365 MSO (version 2206).

Results

Baseline Characteristics

A total of 14 patients with UEDVT who underwent mechanical thrombectomy were included in this analysis. Baseline characteristics for patients are shown in ►**Table 1**. Four patients (28.6%) had a medical history of prior DVT. Two patients presented with concomitant pulmonary embolism diagnosed prior to intervention.

Most patients (85.7%; $n = 12$) had thrombus in two or more vein segments. Thrombus most often involved the subclavian vein and axillary vein (71.4%). The median reported symptom duration was 5 days (IQR: 4, 12). Twelve patients had acute symptoms ($\leq$14 days), and the remaining two patients had symptoms persisting for 21 days and 60 days prior to the procedure. Three patients (21.4%) received previous treatment for their current UEDVT, one with catheter-directed thrombolysis at another facility, another using aspiration thrombectomy with the Indigo Cat8 system (Penumbra, Alameda, California, United States) during the same procedure before the decision was made to switch to the study device due to significant residual thrombus, and the third with a 16-Fr Penumbra device and an 8-Fr AngioJet device (Boston Scientific, Marlborough, Massachusetts, United States) followed by 10-mm and 12-mm balloon venoplasties.

Table 1 Patient characteristics at baseline

Characteristics	Patients ($N = 14$) Median (IQR) or *n* (%)
Age, y	44 (33.5, 57)
Female sex	7 (50)
Medical history	
Malignancy	3 (21.4)
Hypercoagulable disorder	2 (14.3)
Indwelling UE lines	6 (42.9)
Contraindication to thrombolytics	2 (14.3)
Diagnosis	
Primary UEDVT	8 (57.1)
Secondary UEDVT	6 (42.9)
At presentation	
Receiving anticoagulation	3 (21.4)
Limb ischemia	0 (0)
Limb edema	14 (100)
Thrombus location[a]	
Subclavian	13 (92.9)
Axillary	10 (71.4)
Brachial	4 (28.6)
Basilic	5 (35.7)
Brachiocephalic	4 (28.6)
Cephalic	1 (7.1)
Laterality	
Right	6 (42.9)
Left	8 (57.1)

Abbreviations: IQR, interquartile range; UE, upper extremity; UEDVT, upper extremity deep vein thrombosis.
Note: Values are median (IQR) or *n* (%).
[a]Subcategories are not mutually exclusive.

Procedural Characteristics

All procedures were completed under conscious sedation. Basilic vein access was obtained in all cases. Twelve procedures involved adjunctive venoplasty (►**Table 2**). Stent placement was required in two patients who developed brachiocephalic DVT following placement of a tunneled dialysis catheter. In one case, stent placement was performed to address anticipated central vein stenosis following thrombectomy given the patient's history of end-stage renal disease and hemodialysis dependence. In the second patient, the stent was placed due to recoil of the subclavian vein immediately following venoplasty. Adjunctive thrombolytics were not used in any case, and no patients required blood transfusion.

Procedural Outcomes

Technical success was achieved in all mechanical thrombectomy procedures, with $\geq$75% of thrombus removal in all targeted venous segments. Images from a representative example case are shown in ►**Fig. 1**. There were no serious adverse events during the procedure. One patient had minor bleeding from the access site, which resolved with manual compression, and follow-up hemoglobin levels remained unchanged.

Secondary Outcomes

All procedures were completed in a single session, and the median length of postprocedural hospital stay was 2 days (IQR: 1, 3). All patients were discharged on anticoagulants except one who was discharged on dual antiplatelet therapy. Seven patients were discharged with instructions to use compression therapy. After a median follow-up of 88 days, there were no deaths, and 71.4% of patients had not experienced a pulmonary embolism or rethrombosis.

Four patients experienced rethrombosis, three of whom had underlying PSS. Of the three rethrombosed patients with PSS, one experienced rethrombosis 3 days after the index procedure. Reintervention with the study device was performed with surgical decompression 5 days following the index procedure. This patient then experienced rethrombosis event 28 days after rib resection which was treated with an extended course of anticoagulation. The second patient with PSS had a rethrombosis event 15 days after the index procedure. This patient then experienced a pulmonary embolism 5 days later while holding apixaban for rib resection which was eventually performed 184 days after the index procedure. The patient was followed up for an additional

Table 2 Procedural characteristics

Procedural characteristics	All procedures ($n = 14$)	Primary UEDVT ($n = 8$)	Secondary UEDVT ($n = 6$)
Fluoroscopy duration (IQR), min	13.4 (11.4, 16.4)	12.5 (10.9, 14.7)	17.4 (12.5, 22)
Venoplasty	12 (85.7)	8 (100)	4 (66.7)
10 mm	7 (50)	5 (62.5)	2 (33.3)
12 mm	5 (37.5)	2 (25)	3 (50)
14 mm	5 (37.5)	3 (37.5)	2 (33.3)

Abbreviations: IQR, interquartile range; UEDVT, upper extremity deep vein thrombosis.
Note: Values are median (IQR) or *n* (%).

111 days without incident. A new UEDVT was noted by ultrasound 33 days after the index procedure in the third patient with PSS and rethrombosis, who had received surgical decompression on the same day as the index procedure. Repeat thrombectomy was not performed. The final patient experienced rethrombosis of the superior vena cava (SVC) secondary to hemorrhagic shock and bacteremia 80 days after the index procedure and did not receive repeat thrombectomy due to collateralization of the SVC.

Surgical Decompression

Five of the eight patients with primary UEDVT due to PSS went on to receive surgical decompression during the follow-up period at a median of 33 days (IQR: 5, 61) after the index procedure date. Of these five patients, two had recurrence of UEDVT following surgical decompression at postoperative days 28 and 32. Neither patient underwent any additional procedure or surgery, and both were managed with oral anticoagulant therapy. One patient had a total resolution of UEDVT, while the other went on to develop a chronic, partially occlusive subclavian thrombus. Three patients with primary UEDVT due to PSS who underwent surgery did not experience recurrence of UEDVT during the subsequent follow-up period over a median 358 days (IQR: 235, 773). Of the three patients with primary UEDVT due to PSS who did not receive surgical decompression, two initially had surgical decompression scheduled but instead elected for long-term anticoagulation, and the final patient was lost to follow-up.

Discussion

This analysis assessed mechanical thrombectomy for the treatment of UEDVT in a heterogeneous population without excluding patients based on UEDVT etiology, thrombus location, or symptom duration. While the sample size, lack of a comparator arm, and retrospective nature of the study limit its conclusiveness, the data suggest standalone mechanical thrombectomy represents a safe and effective option for UEDVT. This analysis adds to the scarce information on interventional treatment of UEDVT.

While endovascular interventions play an important role in the acute management of UEDVT, surgical resolution of the underlying extrinsic osseous venous compression is most crucial in the definitive management of patients with PSS. Two of the four rethrombosis events occurred in patients burdened with significant residual stenosis secondary to osseous compression while awaiting surgical decompression. Accordingly, the documented cases of rethrombosis are favored secondary to delay in operative intervention.

The mechanical thrombectomy device used in this series is regarded as primarily sized for use in the lower extremities. In all cases, the 13-Fr sheath was employed. Yet, the device size did not present any significant impediment to effective upper extremity use, and there was no clinical evidence of vessel trauma or venous valvular insufficiency. In many cases, the peripheral basilic venous segment accessed was >6 mm.

When specifically compared with thrombolysis, mechanical thrombectomy demonstrates several advantages. Bleeding risk is reduced by virtue of eliminating the use of thrombolytics. Additionally, the lack of thrombolytic infusion obviates the need for intensive care unit admission, potentially decreasing hospital resource utilization.

It is well recognized that thrombus chronicity affects efficacy of interventional treatments for DVT. While symptom duration is often used to estimate thrombus age, it has been shown not to be a wholly reliable indicator,[16] and thrombus in patients with acute symptoms often has a mixture of acute and chronic characteristics upon assessment following mechanical thrombectomy.[17,18] Mechanical thrombectomy with the study device has demonstrated a high rate of success at removing both acute and chronic components,[14,19] while thrombolysis has been shown to be less effective for more aged thrombus.[16] This finding is demonstrated well in this study where technically successful mechanical thrombectomy procedures were completed after a previous therapy for the index UEDVT had failed, including one patient with prior failed catheter-directed thrombolysis and two patients after failed aspiration thrombectomy.

Conclusion

In conclusion, results from this study suggest mechanical thrombectomy provides effective thrombus removal and can be safely performed in patients with UEDVT. Procedures were completed in a single session without the use of adjunctive thrombolytics, and 100% technical success was achieved. There were no major bleeding complications or serious adverse events, and the majority of patients remained free from complications during available follow-up. Additional research in a larger population and

randomized controlled trials is needed to further elucidate long-term outcomes and define the role of mechanical thrombectomy in UEDVT treatment guidelines.

Reporting Guidelines

This article complies with the STROBE guidelines on reporting the results of cohort studies.

Ethics Approval and Consent to Participate

This study was approved by the Indiana University School of Medicine Institutional Review Board under the exempt process. For this type of study, formal research ethics committee review, informed consent, or consent for publication are not required. The research was performed according to the Declaration of Helsinki principles.

Authors' Contribution

T.P. and C.M.D. contributed to the conceptualization, design, literature search, data acquisition and analysis, statistical analysis, and manuscript preparation, editing, and review. . S.D.B. contributed to the conceptualization, design, literature search, data acquisition, data analysis, and manuscript editing and review. S.D.B. takes responsibility for the integrity of the work as guarantor.

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Conflicts of Interest

Dr. Pebror and Dr. Davis declare no conflict of interest. Dr. Butty has received consultant fees from Inari Medical.

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