Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/radcr

Case Report

Mechanical thrombectomy with the ClotTriever System for upper extremity deep vein thrombosis: A case series ☆,☆☆

Prachi J. Patel, BS[a], *Raja S. Ramaswamy, MD*[b,*]

[a] *Indiana University, Indianapolis, IN, USA*
[b] *Division of Vascular and Interventional Radiology, Community Health Network, Indianapolis, IN, USA*

ARTICLE INFO

Article history:
Received 12 July 2024
Revised 25 September 2024
Accepted 28 September 2024

Keywords:
Upper extremity
Deep vein thrombosis
Mechanical thrombectomy
ClotTriever System
Paget Schroetter syndrome
Interventional radiology

ABSTRACT

Patients with upper extremity deep vein thrombosis (UEDVT) generally present with similar symptoms including arm swelling, erythema, heaviness, or pain. However, this condition is caused by different factors which can influence management decisions. As a result, UEDVT is categorized by primary or secondary etiology. Primary UEDVT is most commonly a result of anatomical subclavian vein compression, whereas secondary UEDVT is most frequently associated with indwelling catheters. Regardless of etiology, anticoagulation therapy is recommended, and interventional treatment is reserved for more severe cases. This series includes outcome data for 8 heterogenous patients treated for UEDVT with mechanical thrombectomy using the ClotTriever System by an interventional radiologist in a single healthcare system. Herein we present procedural imaging for select cases and discuss treatment characteristics and outcomes based on etiology.

Introduction

The incidence of upper extremity deep vein thrombosis (UEDVT) is increasing, albeit at a lower frequency than lower extremity deep vein thrombosis (LEDVT). Over the last decade, endovascular management of LEDVT has been well-studied and reported. In contrast, there is a paucity of publications covering the endovascular treatment of UEDVT. The causes of UEDVT can be manifold, with the most common being the development of UEDVT secondary to indwelling venous catheters or leads in the upper extremity [1]. Less commonly, UEDVT develops due to primary anatomical compression of the subclavian vein, usually in patients who perform repetitive strenuous arm motions, also known as Paget Schroetter syndrome (PSS). Whether of primary or secondary etiology, the goal of UEDVT treatment is to clear venous outflow obstruction and restore patency. Although anticoagulation therapy

☆ Competing Interests: The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dr. Patel declares no competing interests. Dr. Ramaswamy has received consulting fees from Inari Medical.
☆☆ Acknowledgments: Writing and editorial support was provided by Kelly Koch, PharmD.
* Corresponding author.
E-mail address: RRamaswamy@ecommunity.com (R.S. Ramaswamy).
https://doi.org/10.1016/j.radcr.2024.09.145

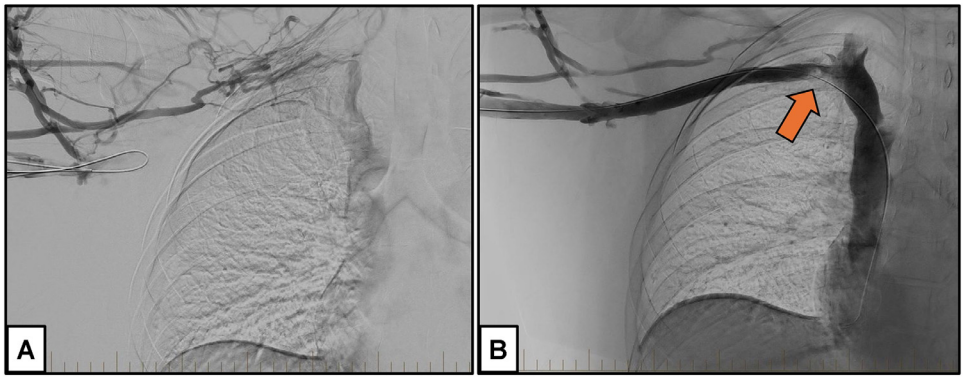

Fig. 1 – Procedural images for a young adult patient with Paget Schroetter syndrome affecting the right upper extremity who underwent treatment with mechanical thrombectomy. The procedure was successful as depicted by the (A) prethrombectomy venogram, in which there is no flow present in the subclavian vein, and the (B) post-thrombectomy venogram, in which flow is restored following an estimated thrombus removal of >95%. Residual stenosis at the compression site (arrow) was later treated surgically via first rib resection.

alone can accomplish this in some cases, more invasive treatment is generally required when subclavian and axillary vein thrombosis causes severe and problematic symptoms. Interventional treatment may lead to better outcomes for UEDVT patients [2,3].

For this series we completed a case review for all 8 patients who underwent mechanical thrombectomy for UEDVT using the ClotTriever System (Inari Medical, Irvine, CA, USA) at our center between September 2022 and December 2023. Data collection included patient demographics; procedural characteristics and outcomes (technical success, estimated thrombus removal, presence of flow on venogram); length of postprocedural hospital stay; and rethrombosis, pulmonary embolism, and death through last interventional radiology follow-up. To assess longer term outcomes based on etiology, we reviewed electronic records to identify readmissions, reinterventions, and deaths occurring within 6 months of the procedure. We aimed to describe the treatment course and outcomes of patients who underwent mechanical thrombectomy for UEDVT.

Case presentation

Case 1

A 23-year-old male was referred to Interventional Radiology by Vascular Surgery for the treatment of primary right UEDVT (PSS). The patient had no prior history of venous thromboembolism (VTE), malignancy or other hypercoagulable condition, and had a symptom duration of 14 days. The patient underwent thrombectomy as an outpatient procedure. As shown in Fig. 1, the thrombectomy was successful, with >95% thrombus removal and the restoration of venous blood flow. Residual stenosis was present, and the patient was scheduled for surgical decompression with Vascular Surgery, which was successfully completed 22 days post thrombectomy. The patient did not have complications through the last follow up with interventional radiology at 35 days. Within 6 months of thrombectomy, the patient did not require reintervention beyond the planned surgical readmission.

Case #2

A 60-year-old male was referred from Hematology for outpatient treatment of left UEDVT which developed secondary to a left chest wall port. The patient had a history of malignancy but had not been previously affected by VTE. At the time of the procedure, the patient had been experiencing symptoms for approximately 1 month and was found to have extensive acute-on-chronic thrombosis of the upper extremity including involvement of the brachiocephalic and basilic veins. Procedural images are provided in Fig. 2. The left chest wall port was removed and mechanical thrombectomy was conducted successfully with >75% thrombus removal and the restoration of in line flow. Following thrombectomy and venoplasty, residual stenosis of the subclavian vein necessitated stent placement with a Zilver Vena stent (Cook Medical, Limerick, Ireland). Additionally, the patient underwent placement of a new right chest wall port. There were no acute complications at last follow-up (54 days). At 6 months post procedure, the patient had not died, been readmitted, or undergone reintervention.

Case #3

A 58-year-old female was referred to Interventional Radiology by a Hospitalist for inpatient treatment of right UEDVT secondary to a peripherally inserted central catheter (PICC). The patient had symptoms persisting for 6 days and did not have a history of VTE or malignancy. Duplex ultrasound investigation of the right subclavian vein revealed limited inflow (Fig. 3). Preprocedural venogram confirmed the presence of an occlusive UEDVT from the right distal basilic vein to the right subclavian vein. The patient underwent mechanical thrombectomy and venoplasty which was successful in restoring inline flow in the right upper extremity. The estimated procedural blood loss was 50 mL. During the same procedure, the PICC line was

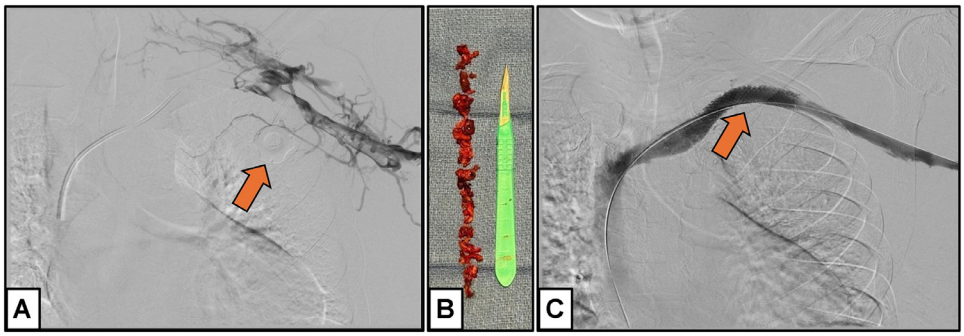

Fig. 2 – Procedural images for a middle-aged patient with port-induced deep vein thrombosis of the left upper extremity treated via mechanical thrombectomy with adjunct venoplasty and stent placement. As shown by the (A) preprocedural venogram, venous flow is absent in the area surrounding the left chest wall port (arrow) with possible collateral formation. After port removal, thrombectomy was conducted and (B) acute-on-chronic thrombus material was extracted. Following thrombectomy and venoplasty, residual stenosis was addressed by stent placement across the left subclavian vein (arrow) which is shown on the (C) postprocedural venogram.

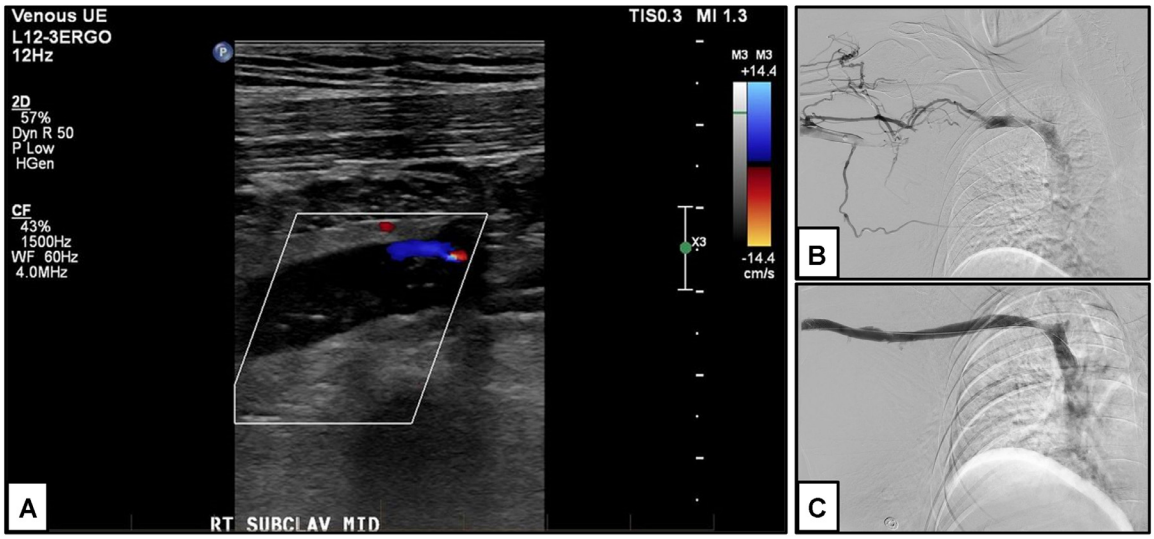

Fig. 3 – Procedural images for a middle-aged patient with right UEDVT secondary to an indwelling peripherally inserted central catheter who underwent mechanical thrombectomy. The (A) prethrombectomy duplex ultrasound of the right upper extremity revealed limited flow into the subclavian vein and (B) prethrombectomy venogram confirmed extensive thrombosis from distal basilic vein to the subclavian vein. As shown on the (C) post-thrombectomy venogram, thrombectomy was completed with >90% thrombus removal and restoration of inline flow.

replaced with a right internal jugular PowerLine central venous catheter (Becton Dickinson, Tempe, AZ, USA). Following the procedure, the patient remained stable and was hospitalized for 13 days. There were no related complications through last follow-up, which occurred 28 days post procedure, approximately 2 weeks after hospital discharge. Through 6 months post thrombectomy the patient had a non-VTE-related readmission for a urinary tract infection. The patient did not require reintervention.

Case #4

An 81-year-old male inpatient was referred to Interventional Radiology by the Hospitalist for treatment of right UEDVT secondary to PICC line and a symptom duration of 2 days. The patient's medical history did not include prior VTE or malignancy. Procedural images are shown in Fig. 4. Prethrombectomy, thrombosis extending from the right basilic to right subclavian vein was identified. Post-thrombectomy, the right basilic to right subclavian vein was completely patent with near complete thrombus removal (>95%). Stenosis of the right brachiocephalic vein was treated with 12 mm balloon venoplasty. During the procedure, the previous right upper extremity PICC was removed, and a left internal jugular tunneled PowerLine catheter was placed. The estimated blood loss for the procedure was 20 mL. The patient was discharged 6 days post procedure and completed last follow-up with Interventional Radiology approximately 2 months later at 65 days post

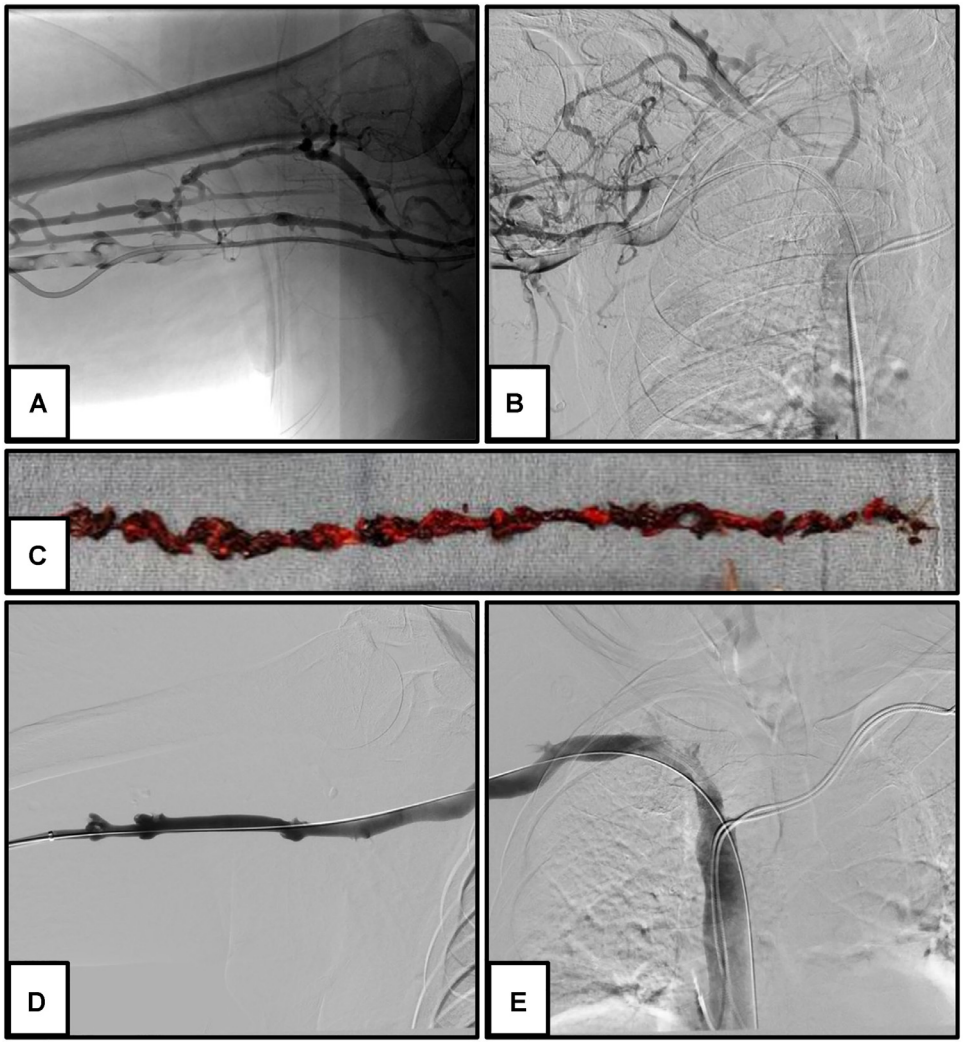

Fig. 4 – Procedural images for an elderly patient with right UEDVT secondary to a peripherally inserted central catheter who underwent mechanical thrombectomy and venoplasty. Two images from prethrombectomy venogram investigation are shown in panel (A) and (B), highlighting extensive thrombosis obstructing flow from distal basilic vein to the subclavian vein. The acute to subacute thrombus material extracted via thrombectomy is shown in panel (C). Two images from the post-thrombectomy venogram are shown in panel (D) and (E) which demonstrate the restoration of flow following near complete thrombus removal.

procedure. Medical records did not indicate death, readmission, or reintervention within 6 months post thrombectomy.

Summarized outcomes by UEDVT etiology

Case details and outcomes for all 8 patients are shown in Table 1. The median age was 62 years [interquartile range (IQR): 53, 66] and the majority of patients (75%) were male. All cases involved thrombosis of the subclavian and axillary veins. Patients with primary UEDVT were younger, and thrombus location was limited to the subclavian and axillary veins. Among patients with secondary UEDVT, 1 had cephalic involvement, 1 had brachial involvement, 1 had basilic involvement, and 1 had brachiocephalic and basilic vein involvement. In both groups, the majority of cases involved the right upper extremity, and the median reported symptoms duration was approximately 1 week.

All cases were completed under conscious sedation and with basilic vein access. Median fluoroscopy duration was comparable for primary and secondary UEDVT (<10 minutes). All cases involved venoplasty and no cases involved adjunct thrombolytics. One patient with secondary UEDVT received a stent. Procedural outcomes were similar for primary and secondary UEDVT. Technical success was achieved in all cases. Thrombus removal was estimated to be >75% in 2 cases, >90% in 1 case, and >95% in 5 cases. Before thrombectomy, venous blood flow on venogram was only present in 2 cases (25%). Following thrombectomy, venous blood flow was present in 100%.

Four patients (50.0%) had residual stenosis following the thrombectomy procedure. As expected per etiology, residual stenosis was observed in the 3 patients with primary UEDVT.

Table 1 – Patient characteristics and outcomes following mechanical thrombectomy and adjuvant venoplasty for primary or secondary UEDVT.

Variable	All patients (n = 8)	Primary UEDVT (n = 3)	Secondary UEDVT (n = 5)
Age, years	62.0 (53.0, 66.0)	38.0 (30.5, 51.5)	64.0 (60.0, 69.0)
Male sex	6 (75.0)	3 (100.0)	3 (60.0)
Right limb affected	6 (75.0)	3 (100.0)	3 (60.0)
Symptom duration, days	7.0 (3.5, 9.5)	8.0 (6.0, 11.0)	6.0 (2.0, 8.0)
Thrombus vein location			
Subclavian	8 (100.0)	3 (100.0)	5 (100.0)
Axillary	8 (100.0)	3 (100.0)	5 (100.0)
Basilic	2 (25.0)	0 (0.0)	2 (40.0)
Brachiocephalic	1 (12.5)	0 (0.0)	1 (20.0)
Cephalic	1 (12.5)	0 (0.0)	1 (20.0)
Brachial	1 (12.5)	0 (0.0)	1 (20.0)
Fluoroscopy duration, min	6.2 (5.1, 8.0)	8.0 (6.7, 8.1)	5.1 (5.0, 7.0)
Est. thrombus removal[a]			
>95%	5 (62.5)	2 (66.6)	3 (60.0)
>90%	1 (12.5)	0 (0.0)	1 (20.0)
>75%	2 (25.0)	1 (33.3)	1 (20.0)
Technical success	8 (100.0)	3 (100.0)	5 (100.0)
Flow present[b]	8 (100.0)	3 (100.0)	5 (100.0)
Residual stenosis[b]	4 (50.0)	3 (100.0)	1 (20.0)
Postprocedure stay, days	3.0 (0.0, 14.8)	0.0 (0.0, 0.0)	13.0 (6.0, 20.0)
Follow up duration, days	59.5 (44.0, 78.0)	76.0 (55.5, 111.5)	54.0 (47.0, 65.0)
6-month readmission	6 (80.0)	3 (100.0)[c]	3 (60.0)[c]
VTE-related	0 (0.0)	0 (0.0)	0 (0.0)
6-month reintervention	1 (12.5)	0 (0.0)	1 (20.0)
VTE-related	0 (0.0)	0 (0.0)	0 (0.0)
6-month mortality	2 (25.0)	1 (33.3)	1 (20.0)
VTE-related	0 (0.0)	0 (0.0)	0 (0.0)

Abbreviations: UEDVT, upper extremity deep vein thrombosis; VTE, venous thromboembolism.
[a] Thrombus removal was estimated by comparing pre and postprocedural venograms.
[b] Flow present and residual stenosis on postprocedural venogram.
[c] Primary UEDVT readmissions: preplanned surgical decompression with vascular surgery (n = 2), hepatic encephalopathy (n = 1). Secondary UEDVT readmissions: cerebral infarct (n = 1), intraabdominal abscess in the setting of colon cancer (n = 1), urinary tract infection (n = 1).

Two of the 3 later underwent surgical decompression at 22 and 116 days after thrombectomy. The third primary UEDVT patient was referred to Vascular Surgery for assessment but had not undergone surgical decompression as of last follow-up (76 days post thrombectomy). Medical records revealed this patient had died from an unrelated condition within 6 months. The single patient with secondary UEDVT who had residual stenosis following thrombectomy received a stent. This patient had a reported symptom duration of 29 days and was the only patient in the series with a symptom duration >14 days.

All cases were completed in a single session. There were no device- or procedure-related adverse events. No patients required a blood transfusion. There were no treatment-related postprocedural intensive care unit admissions. The median length of postprocedural hospital stay was 3 days [0.0, 14.8], 4 patients were treated in an outpatient setting, and all patients were discharged on anticoagulation. All 3 patients with primary UEDVT were treated as outpatient, compared to 1 patient with secondary UEDVT. Symptom improvement was observed in all patients. Limb edema was fully resolved in all 4 inpatients by hospital discharge. In the 4 outpatients, limb edema was still present at the time of discharge, though improvements from baseline physical exam were noted in all cases.

After a median follow-up of 59.5 days [44.0, 78.0], there were no cases of rethrombosis, pulmonary embolism, or death. Through 6 months post treatment, there were no VTE-related readmissions, reinterventions, or deaths. Two patients died within 6 months of treatment, one patient was readmitted for hepatic encephalopathy and died of hepatic cirrhosis and the second patient was readmitted for intraabdominal abscess in the setting of colon cancer and died of sepsis.

Discussion

The outcomes observed in this series show that mechanical thrombectomy with adjunct venoplasty provided effective UEDVT thrombus removal and flow restoration without the use of thrombolytics. Patient cases were heterogeneous in UEDVT etiology and completed with no acute complications or adverse events through follow-up. There were no VTE-related readmissions, reinterventions, or deaths within 6 months of thrombectomy.

The incidence of UEDVT is rising, primarily due to the increased use of indwelling catheters and leads. A community-based study in western France reported that UEDVT accounted for 14% of proximal DVT cases involving peripheral vasculature [4]. In the Japanese COMMAND-VTE registry, UEDVT patients represented only 3% of DVT cases [5]. The current overall prevalence of UEDVT is likely between these 2 figures, generally reported as accounting for 5-10% of all DVT cases. In the MITH study, Winters et al. reported that UEDVT accounted for 51% of all hospital-acquired DVT cases in medical inpatients, and the use of central venous catheters was associated with a 14-fold increase in the likelihood of UEDVT [6]. As such, it is important to understand the available treatment strategies for these patients in the event that intervention is required.

Here, we summarize previously published single-center retrospective investigations of the ClotTriever System for UEDVT treatment. The results of this series are consistent with outcomes reported by Sweeney et al. for 14 patients who similarly had various presentations of UEDVT categorized as benign, infectious, or malignant. All cases were technically and clinically successful, and there were no intraprocedural adverse events [7]. Similar outcomes were also reported in 3 published case reports for patients with catheter-related secondary UEDVT (n = 2) and thoracic outlet syndrome primary UEDVT (n = 1) successfully treated with the ClotTriever System [8–10].

The results of this series also appear consistent with outcomes following the treatment of acute primary UEDVT with other endovascular devices, including catheter-directed thrombolysis (CDT) and aspiration thrombectomy; however, patients with secondary UEDVT were excluded from these studies [11–13]. Following treatment with CDT and venoplasty for UEDVT (n = 12), Jenab et al. reported all patients had ≤50% residual stenosis with no serious complications through one year of follow-up, and there was only one case of recurrence requiring surgical decompression [12]. Fuller et al. assessed 22 patients treated with aspiration thrombectomy (with or without adjunct thrombolytics) or various forms of CDT (with or without a pharmacomechanical component). All cases were completed with >70% thrombus removal and no procedural complications [13].

In the absence of randomized trial data, surgical decompression is generally performed for patients with primary UEDVT based on data indicating patients who undergo rib resection have fewer long-term symptoms [14]. Still, it is unknown how long after an interventional procedure surgical decompression should be performed [15]. In our series, 2 of the 3 primary UEDVT patients later underwent surgical decompression (1 within 1 month and 1 within 4 months). The third primary UEDVT patient was referred to Vascular Surgery for assessment but did not undergo surgical decompression and ultimately died due to hepatic cirrhosis within 6 months of the procedure. Similar to primary UEDVT, more studies are needed to determine a recommended interventional treatment approach for secondary UEDVT patients [15]. In this series, we presented 3 cases in which the central venous catheter associated with the thrombosis was removed and later replaced based on severe symptoms and the need for interventional treatment. In less serious cases treated with therapeutic anticoagulation, removal of the central venous is not required if it is still necessary and functional [16].

In conclusion, this series indicates mechanical thrombectomy without adjunctive thrombolytics can be safely and successfully completed in patients with UEDVT of varying presentations. As the incidence of UEDVT is increasing, future prospective studies of this treatment strategy are warranted.

Patient consent

Written informed consent for the publication of this case series was obtained from the patients.

Ethical approval

Formal consent is not required for this type of study.

REFERENCES

[1] Geerts W. Central venous catheter-related thrombosis. Hematology Am Soc Hematol Educ Program 2014;2014:306–11. doi:10.1182/asheducation-2014.1.306.
[2] de Kleijn R, Schropp L, Westerink J, Nijkeuter M, van Laanen J, Teijink J, et al. Current treatment strategies for primary upper extremity deep venous thrombosis; a retrospective observational multicenter case series. Front Surg 2022;9:1080584. doi:10.3389/fsurg.2022.1080584.
[3] Rosa V, Chaar CIO, Espitia O, Otalora S, Lopez-Jimenez L, Ruiz-Sada P, et al. A RIETE registry analysis of patients with upper extremity deep vein thrombosis and thoracic outlet syndrome. Thromb Res 2022;213:65–70. doi:10.1016/j.thromres.2021.12.030.
[4] Delluc A, Le Mao R, Tromeur C, Chambry N, Rault-Nagel H, Bressollette L, et al. Incidence of upper-extremity deep vein thrombosis in western France: a community-based study. Haematologica 2019;104:e29–31. doi:10.3324/haematol.2018.194951.
[5] Yamashita Y, Morimoto T, Amano H, Takase T, Hiramori S, Kim K, et al. Deep vein thrombosis in upper extremities: clinical characteristics, management strategies and long-term outcomes from the COMMAND VTE Registry. Thromb Res 2019;177:1–9. doi:10.1016/j.thromres.2019.02.029.
[6] Winters JP, Callas PW, Cushman M, Repp AB, Zakai NA. Central venous catheters and upper extremity deep vein thrombosis in medical inpatients: the medical inpatients and thrombosis (MITH) study. J Thromb Haemost 2015;13:2155–60. doi:10.1111/jth.13131.
[7] Sweeney AM, Makary MS, Greenberg C, Chick JFB, Abad-Santos M, Monroe EJ, et al. Percutaneous thrombectomy of upper extremity and thoracic central veins using Inari ClotTriever System: experience in 14 patients. J Vasc Surg Cases Innov Tech 2023;9:101096. doi:10.1016/j.jvscit.2023.101096.
[8] Harmon D, Dabaja W, Qaqi O. A novel interventional approach to upper extremity swelling. J Vasc Surg Cases Innov Tech 2020;6:209–11. doi:10.1016/j.jvscit.2020.02.010.
[9] Agarwal S, Sosnofsky C, Saum J, Aggarwal M, Patel S. Single-session treatment of upper extremity deep venous

thrombosis and central venous catheter malfunction using the ClotTriever System. Cureus 2020. doi:10.7759/cureus.12071.
[10] Discalzi A, Cignini V, Ciferri F, Nardelli F, Rossato D, Calandri M, et al. Successful endovascular thrombectomy with the ClotTriever System for acute subclavian vein thrombosis in venous thoracic outlet syndrome. CVIR Endovasc 2023;6:32. doi:10.1186/s42155-023-00378-7.
[11] Teter K, Arko F, Muck P, Lamparello PJ, Khaja MS, Huasen B, et al. Aspiration thrombectomy for the management of acute deep venous thrombosis in the setting of venous thoracic outlet syndrome. Vascular 2020;28:183–8. doi:10.1177/1708538119895833.
[12] Jenab Y, Tofighi S, Ayati A, Rezvanimehr A, Moosavi NS, Jalaie H, et al. Single-center experience with catheter-directed thrombolysis and balloon angioplasty for acute upper-extremity deep vein thrombosis: a case series study. BMC Cardiovasc Disord 2023;23:351. doi:10.1186/s12872-023-03389-3.
[13] Fuller T, Neville E, Shapiro J, Muck AE, Broering M, Kulwicki A, et al. Comparison of aspiration thrombectomy to other endovascular therapies for proximal upper extremity deep venous thrombosis. J Vasc Surg Venous Lymphat Disord 2022;10:300–5. doi:10.1016/j.jvsv.2021.07.017.
[14] Lugo J, Tanious A, Armstrong P, Back M, Johnson B, Shames M, et al. Acute Paget-Schroetter syndrome: does the first rib routinely need to be removed after thrombolysis? Ann Vasc Surg 2015;29:1073–7. doi:10.1016/j.avsg.2015.02.006.
[15] 15 Carlon TA, Sudheendra D. Interventional therapy for upper extremity deep vein thrombosis. Semin Intervent Radiol 2017;34:54–60. doi:10.1055/s-0036-1597764.
[16] Crawford JD, Liem TK, Moneta GL. Management of catheter-associated upper extremity deep venous thrombosis. J. Vasc. Surg. 2016;4(3):375–9. doi:10.1016/j.jvsv.2015.06.003.