

Case Report

Removal of Wall-Adherent Inferior Vena Cava Thrombus with a Combined Approach Using Vacuum-Assisted Thrombectomy and a Rotational Thrombectomy Device

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Introduction. Large thrombi in the inferior vena cava pose a high risk for a pulmonary embolism. Percutaneous extracorporeal circulation-based vacuum-assisted thrombus aspiration is a viable option for removal. Wall adherence of thrombotic material can compromise procedural success. **Case Report.** A 46-year-old female presented with a subtotal thrombotic occlusion of the inferior vena cava and the proximal right common iliac vein after weaning from extracorporeal life support. Due to severe wall adherence of the thrombotic material, the patient was treated with the combination of percutaneous extracorporeal circulation-based thrombus aspiration using the AngioVac system and a rotational thrombectomy device.

1. Introduction

Extracorporeal life support-associated thrombosis in the deep venous system is a known complication [1]. Large thrombi in the inferior vena cava pose a high risk for a pulmonary embolism and are an indication of thrombectomy or lysis [2, 3]. Percutaneous extracorporeal circulation-based thrombus aspiration with the AngioVac system has proved to be a feasible alternative to surgical removal or medical thrombolysis [4]. However, wall-adherent thrombi can compromise the procedural success of vacuum-assisted thrombectomy. This case report describes a strategy for the removal of a large thrombus extending from the proximal

right common iliac vein through the entire inferior vena cava (IVC) through a combination of extracorporeal circulation-based percutaneous vacuum-assisted thrombectomy and rotational thrombectomy to increase the procedural success rate in wall-adherent central deep vein thrombosis.

2. Case Report

A 46-year-old female was admitted due to a subtotal thrombotic occlusion of the entire IVC and the proximal right common iliac vein after decannulation from extracorporeal life support which was confirmed by computed tomography angiography (CTA) (Figure 1). Prior to admission, the

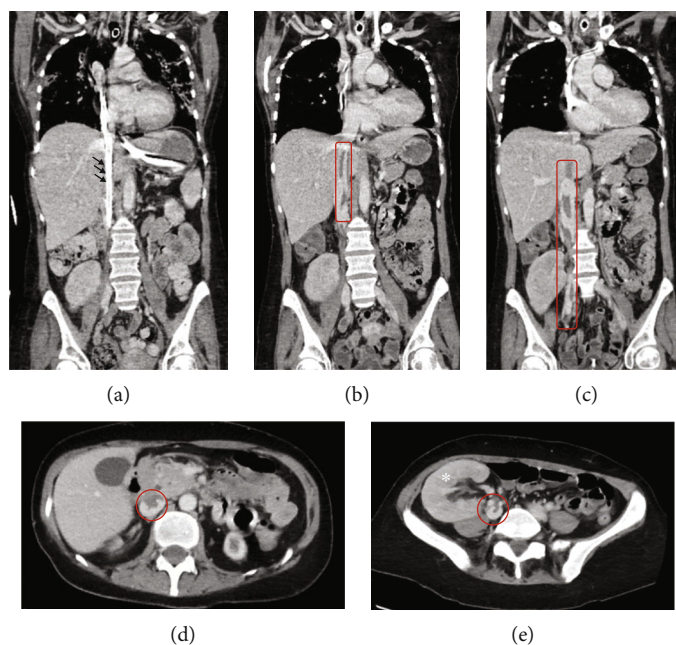


FIGURE 1: Preoperative computed tomography angiography (CTA) confirming the diagnosis of inferior vena cava and right proximal iliac vein thrombosis. (a) The black arrows mark the ECMO cannula prior to decannulation localized in the inferior vena cava. (b, c) After removal of the venous ECMO cannula, CTA shows extensive thrombosis of the inferior vena cava and the proximal right iliac vein as highlighted by the red box. (d) Subtotal occlusion of the inferior vena cava at the level of the liver is highlighted by the red circle. (e) Subtotal occlusion of the vessel lumen next to the heterotopic kidney transplant (* marking the kidney transplant).

patient had been treated in a medical intensive care unit for severe COVID-19 pneumonia and required veno-venous extracorporeal membrane oxygenation (vv-ECMO) for 36 days. The patient was status post kidney transplant under immunosuppressive therapy. Prior to vv-ECMO initiation, the patient was on prophylactic anticoagulation with heparin. Once ECMO support was established, anticoagulation was intensified with unfractionated heparin with a therapeutic partial thromboplastin time (PTT) target. Due to the extensive thrombosis with subtotal occlusion of the inferior vena cava and right iliac vein and the risk for pulmonary embolization, the patient was allocated to mechanical thrombectomy after a multidisciplinary decision-making process.

On presentation, the patient was hemodynamically stable without the need for catecholamines and required only low-flow oxygen supplementation via an existing tracheostomy. The patient was transferred directly to the hybrid operating room.

After induction of general anesthesia, a 6 French (F) sheath was placed in the right internal jugular vein. Preoperative transesophageal echo (TEE) showed good biventricular function and only mild tricuspid regurgitation.

As described in detail by Haupt et al. [5], the veno-venous extracorporeal circuit used at our institution for percutaneous aspiration procedures consists of the 22 F AngioVac (Gen 3) 20° suction cannula (AngioDynamics, Latham, NY, USA) for venous drainage, a CAPIOX® BT15 bubble trap (Terumo Cardiovascular, Ann Arbor, MI, USA) as a filter for aspirated thrombotic material, a centrifugal pump (Revolution 5, LivaNova, Mirandola, IT), and a 16 F Edwards Fem-Flex II cannula (Edwards Lifesciences,

Irvine, CA, USA) for venous return. During the procedure, heparin is used for anticoagulation with a target-activated clotting time of 250 to 300 seconds. During these procedures, the negative pressure created at the tip of the aspiration cannula ranges between -2 mmHg in phases of recirculation and above -300 mmHg in the moment of aspiration of thrombotic material [5]. The setup used in this case is shown in Figure 2.

As a first step, the right femoral vein was cannulated percutaneously with an 8 F sheath, followed by venography of the IVC via the same access. In line with preoperative diagnostic studies, the venogram revealed a subtotal thrombotic occlusion of the IVC and the proximal right common iliac vein (Figure 3(a)).

After systemic heparin administration, a 16 F Edwards Fem-Flex II cannula (Edwards Lifesciences, Irvine, CA, USA) was introduced into the left femoral vein for venous return using Seldinger's technique. The 6 F sheath in the right jugular vein was exchanged via an Amplatz Ultra Stiff guidewire (Cook Medical, Bloomington, IN, USA) for a 26 F Gore Dry Seal sheath (W.L. Gore & Associates, Inc., Flagstaff, AZ, USA). As a last step prior to initiation of the extracorporeal circuit, the 22 F AngioVac (Gen 3) 20° angled tip cannula (AngioDynamics, Latham, NY, USA) was introduced via the 26 F sheath, and both the return cannula and the AngioVac suction cannula were connected to the extracorporeal circuit.

The extracorporeal circulation was started, and thrombotic material in the IVC and the proximal right common iliac vein was aspirated under continuous monitoring with TEE and fluoroscopy. Due to severe wall adherence of large

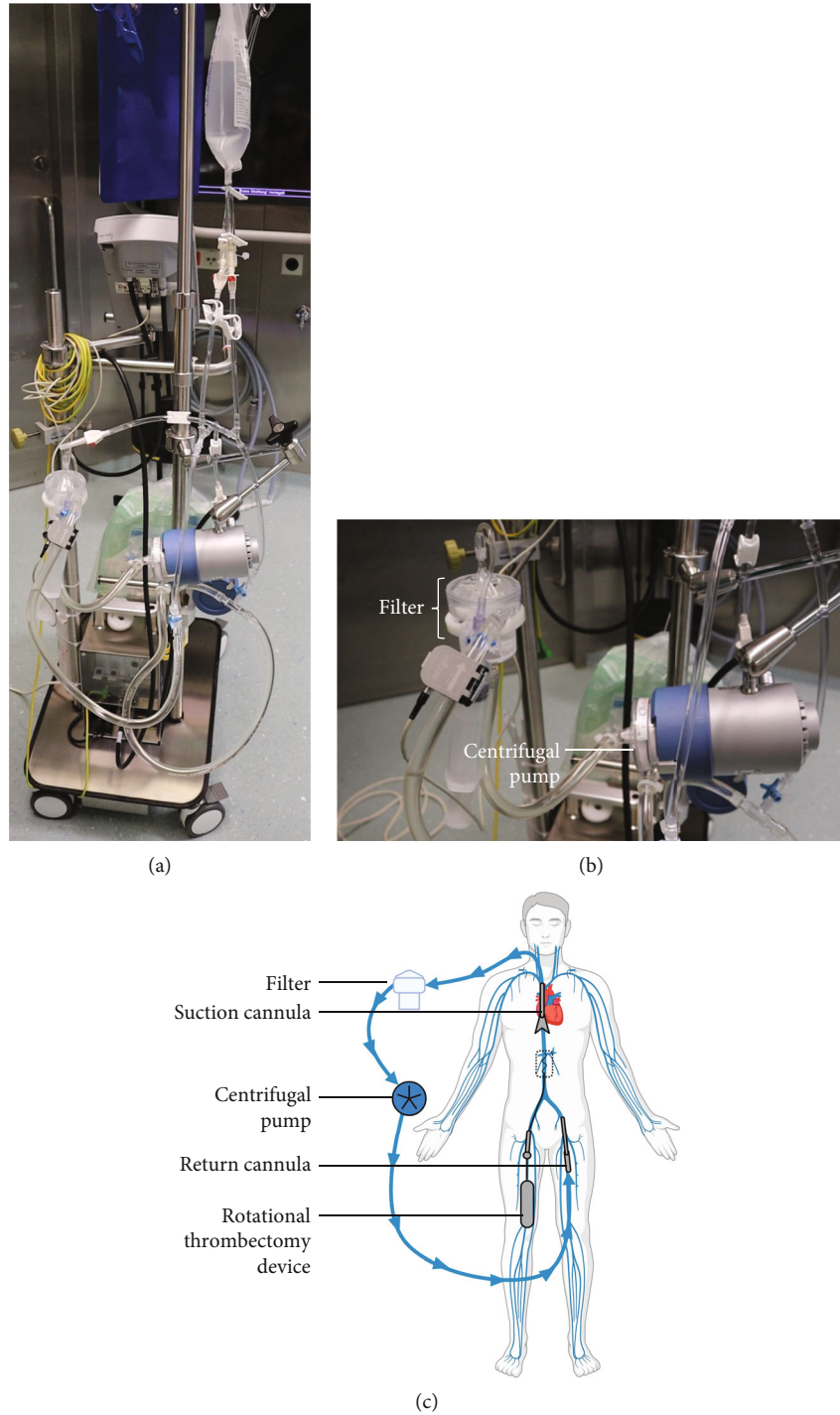


FIGURE 2: Setup of the AngioVac system. (a) Depicted is the primed extracorporeal circuit prior to connection to the patient. (b) Focused view of the filter and the centrifugal pump. (c) Schematic illustration of the application of the AngioVac system in combination with the Cleaner 15™ rotational thrombectomy device. In this case, due to thrombus formation in the inferior vena cava and the right iliac vein, the suction cannula was introduced into the right jugular vein, and venous return was administered via the left femoral vein. The rotational thrombectomy device was introduced via the right femoral vein. The dotted area shows the released sinusoidal wire of the thrombectomy device just distally of the AngioVac suction cannula.

portions of the thrombotic material, a rotational thrombectomy system Cleaner 15™ (Argon Medical Devices, Plano, TX, USA) was introduced via the 8F sheath in the right

femoral vein. The tip of the AngioVac cannula was placed just cranially to the tip of the released sinusoidal wire of the rotational thrombectomy device (Figure 4(a)). The



FIGURE 3: Pre- and postinterventional venogram of the inferior vena cava. (a) Preoperative venogram shows a subtotal occlusion of the inferior vena cava. The asterisk marks the remaining lumen of the IVC. (b) After the procedure, the lumen of the inferior vena cava is restored. The dotted cone shows the tip of the suction cannula.

thrombectomy system was engaged under continuous aspiration, and the wall-adherent thrombus in the IVC and the right iliac vein were mobilized (Figure 4(b)) and simultaneously evacuated. After the thrombotic material was safely removed (Figure 5), the extracorporeal circulation was discontinued.

In order to evaluate the procedural success, another venography was performed which showed almost complete removal of the thrombotic material (Figure 3(b)). The last steps comprised the removal of the cannulas and the sheaths, followed by the closure of the skin incisions with sutures.

Postprocedural TEE showed no change in ventricular contractility, no new valvulopathy, and no signs of pulmonary embolism.

Completion of the procedure was followed by weaning from anesthesia. Once the patient resumed spontaneous breathing under low-flow oxygen supplementation, she was transferred back to the medical ICU with stable hemodynamics. The total duration of the surgical procedure was 68 min, and the patient was mechanically ventilated for 150 min. After the procedure, the patient received therapeutic anticoagulation with low-molecular-weight heparin. During the further postoperative course, the patient was switched to therapeutic anticoagulation with a direct oral anticoagulant (DOAC). By her discharge on the 19th postoperative day, the patient had recovered well and was transferred to a rehabilitation facility in hemodynamic and respiratory stability. Therapeutic anticoagulation was indicated for at least 3 to 6 months after discharge.

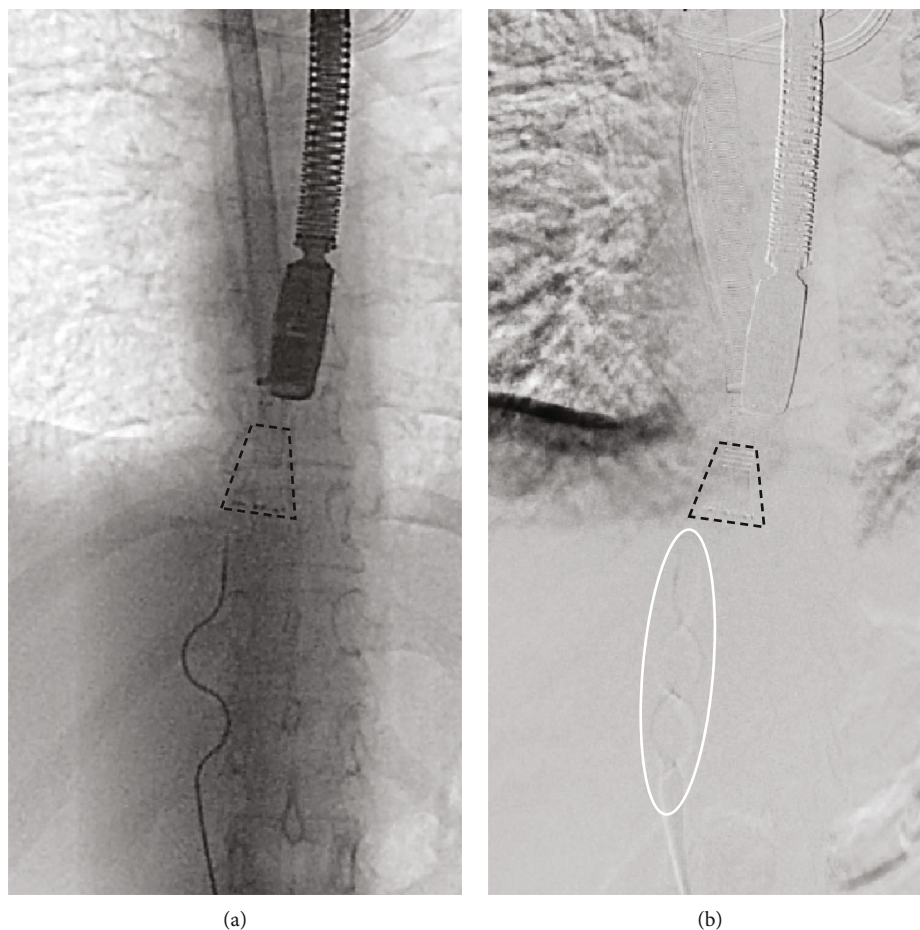


FIGURE 4: Mobilization of wall-adherent thrombus with the rotational thrombectomy device. (a) The funnel at the tip (dotted cone) of the AngioVac cannula is positioned just proximal to the tip of the Cleaner 15™ thrombectomy device. Note that the sinusoidal wire has been released from the catheter of the rotational thrombectomy device. (b) Under continuous aspiration of the AngioVac system, the rotational thrombectomy device is engaged, and the sinusoidal wire rotates within the vessel. The white ellipsoid shows the rotating action of the sinusoidal wire.

3. Discussion

Vacuum-assisted thrombectomy using the AngioVac device is a well-established technique for debulking large cardiac implantable electronic lead vegetations and tricuspid vegetations in endocarditis [6–8]. Furthermore, it presents a therapeutic option for the treatment of venous thrombosis of central or iliac veins and even pulmonary embolisms [9]. A well-known cause of procedural failure of mechanical and vacuum-assisted thrombectomy is the adherence of chronic thrombus to the vessel wall [4, 10]. This issue can be overcome by using rotational thrombectomy devices such as the Cleaner 15™ since its adjunctive use increases the procedural success in pharmacomechanical thrombectomy. In the case of the Cleaner 15™ rotational thrombectomy device, a sinusoidal wire rotating at 4,000 rpm macerates the thrombus while simultaneously detaching it from the vessel wall [11]. Due to the potential danger of dislodgement of thrombotic material and pulmonary embolisms, these procedures are often performed with a vena cava filter in place [11, 12]. Despite being a known technique for throm-

bectomy in smaller veins such as the femoral veins or AV-fistulas, rotational thrombectomy is not yet established during the use of vacuum-assisted thrombectomy of wall-adherent thrombi in the IVC [13–15].

In the presented case, due to severe wall adherence of the thrombus, vacuum-assisted thrombectomy with the AngioVac device alone did not offer sufficient procedural success. However, the use of the AngioVac allowed for the adjunctive use of the Cleaner 15™ rotational thrombectomy system, since mobilized debris could be aspirated and did not pose a risk of pulmonary embolism in this setting. The combined approach allowed for complete recanalization of the inferior vena cava and the right iliac vein.

The use of a rotational thrombectomy device during percutaneous vacuum-assisted thrombectomy may be a useful addition for the removal of large wall-adherent thrombi in the inferior vena cava and the proximal iliac veins. This technique potentially increases the procedural success rate in patients presenting with chronic wall-adherent thrombi and might be useful in preventing further escalation of surgical therapy.

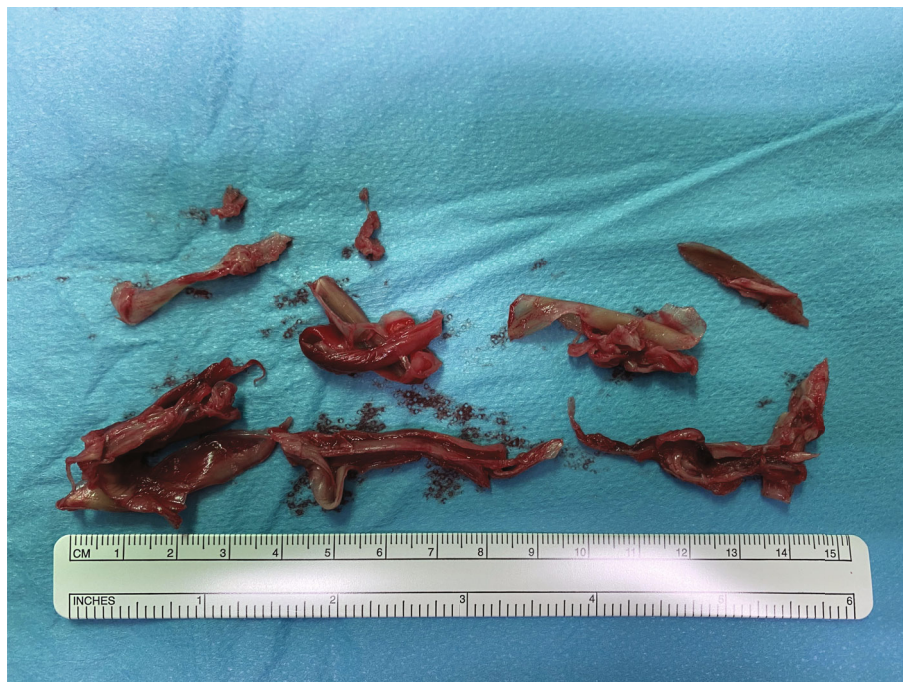


FIGURE 5: Thrombotic material found in the filter of the extracorporeal circuit after the procedure. Pathologic examination showed that the aspirated thrombus material consisted of fibrin with a moderate amount of erythrocytes. No bacterial growth was detected during microbiological testing.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

C.S. received consulting honoraria and speaker fees from AngioDynamics. The other authors have no conflicts of interest to declare.

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The schematic drawing in Figure 2 C was created with <http://Biorender.com>. Open access funding is enabled and organized by Projekt DEAL.

Supplementary Materials

Supplementary material file with a description of key technical aspects for performing the described procedure. (*Supplementary Materials*)

References

- [1] F. Bidar, A. Lancelot, G. Lebreton et al., “venous or arterial thromboses after venoarterial extracorporeal membrane oxygenation support: frequency and risk factors,” *The Journal of Heart and Lung Transplantation*, vol. 40, no. 4, pp. 307–315, 2021.
- [2] S. V. Konstantinides, G. Meyer, C. Becattini et al., “2019 ESC guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS): the task force for the diagnosis and management of acute pulmonary embolism of the European Society of Cardiology (ESC),” *European Heart Journal*, vol. 41, pp. 543–603, 2020.
- [3] M. Ashrafi, S. B. Ahmad, S. A. Antoniou, T. Khan, and G. A. Antoniou, “Treatment strategies for proximal deep vein thrombosis: a network meta-analysis of randomised controlled trials,” *European Journal of Vascular and Endovascular Surgery*, vol. 63, no. 2, pp. 323–334, 2022.
- [4] C. Basman, U. Rashid, Y. J. Parmar, C. Kliger, and I. Kronzon, “The role of percutaneous vacuum-assisted thrombectomy for intracardiac and intravascular pathology,” *Journal of Cardiac Surgery*, vol. 33, no. 10, pp. 666–672, 2018.
- [5] B. Haupt, F. Merkle, T. Dreizler, V. Falk, and C. Starck, “Technical implementation of percutaneous thrombus aspiration using the AngioVac system,” *Perfusion*, vol. 36, no. 4, pp. 352–356, 2021.
- [6] R. H. M. Schaerf, S. Najibi, and J. Conrad, “Percutaneous vacuum-assisted thrombectomy device used for removal of large vegetations on infected pacemaker and defibrillator leads as an adjunct to lead extraction,” *Journal of Atrial Fibrillation*, vol. 9, no. 3, p. 1455, 2016.
- [7] C. T. Starck, T. Dreizler, and V. Falk, “The AngioVac system as a bail-out option in infective valve endocarditis,” *Annals of Cardiothoracic Surgery*, vol. 8, no. 6, pp. 675–677, 2019.
- [8] B. J. George, P. Santos, K. Donaldson et al., “A retrospective comparison of tricuspid valve surgery to tricuspid valve vegetation debulking with AngioVac for isolated tricuspid valve

- endocarditis,” *Journal of the American College of Cardiology*, vol. 73, no. 9, pp. 1973–1973, 2019.
- [9] I. Hameed, C. Lau, F. M. Khan et al., “AngioVac for extraction of venous thromboses and endocardial vegetations: a meta-analysis,” *Journal of Cardiac Surgery*, vol. 34, no. 4, pp. 170–180, 2019.
- [10] L. Turmel-Rodrigues, J. Pengloan, H. Rodrigue et al., “Treatment of failed native arteriovenous fistulae for hemodialysis by interventional radiology,” *Kidney International*, vol. 57, no. 3, pp. 1124–1140, 2000.
- [11] A. Bozkurt, İ. Kirbaş, D. Kösehan, B. Demirçelik, and Y. Nazlı, “Pharmacomechanical thrombectomy in the management of deep vein thrombosis using the cleaner device: an initial single-center experience,” *Annals of Vascular Surgery*, vol. 29, no. 4, pp. 670–674, 2015.
- [12] C. Köksoy, M. F. Yılmaz, H. S. Başbuğ et al., “Pharmacomechanical thrombolysis of symptomatic acute and subacute deep vein thrombosis with a rotational thrombectomy device,” *Journal of Vascular and Interventional Radiology*, vol. 25, no. 12, pp. 1895–1900, 2014.
- [13] B. C. Branco, M. F. Montero-Baker, E. Espinoza et al., “Pharmacomechanical thrombolysis in the management of acute inferior vena cava filter occlusion using the Trellis-8 device,” *Journal of Endovascular Therapy*, vol. 22, no. 1, pp. 99–104, 2015.
- [14] O. Rodoplu, C. E. Yildiz, D. M. Oztas et al., “The efficacy of rotational pharmaco-mechanical thrombectomy in patients with acute iliofemoral deep vein thrombosis: is the standard treatment of deep vein thrombosis changing?,” *Phlebology*, vol. 36, no. 2, pp. 119–126, 2021.
- [15] Y. Golowa, M. Warhit, F. Matsunaga, and J. Cynamon, “Catheter directed interventions for inferior vena cava thrombosis,” *Cardiovascular Diagnosis and Therapy*, vol. 6, no. 6, pp. 612–622, 2016.