

Clinical outcomes of AngioJet rheolytic thrombectomy in the treatment of May–Thurner syndrome-related deep venous thrombosis

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Abstract

Objective: May–Thurner syndrome (MTS) is an anatomic stenotic variation associated with deep vein thrombosis (DVT) of the left leg. The classical DVT treatment strategy is medical treatment without thrombus removal. This study was performed to assess the clinical outcomes of the combination of AngioJet™ rheolytic thrombectomy and stenting for treatment of MTS-related DVT.

Methods: We conducted a retrospective cohort study of patients treated for MTS-related DVT from January 2017 to June 2020 at a single institution.

Results: Fourteen patients (nine women) underwent AngioJet™ rheolytic thrombectomy for MTS-related DVT during the study period. The median DVT onset time was 8 days (interquartile range (IQR), 3–21 days). The median procedure time was 130 minutes (IQR, 91–189 minutes),

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and the median hospital stay was 7 days (IQR, 5–26 days). One patient had a residual thrombus and occluded iliac stent and underwent adjuvant catheter-directed thrombolysis for revascularization. The primary patency rate for the iliac stent was 92.9% at 12 months.

Conclusion: Concomitant AngioJet™ rheolytic thrombectomy and stenting of MTS-induced lesions may be beneficial for patients with MTS-related DVT.

Keywords

May–Thurner syndrome, deep vein thrombosis, thrombectomy, stent, clinical outcome, combination therapy

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Introduction

May–Thurner syndrome (MTS), an anatomic stenotic variation first described by May and Thurner,¹ is characterized by symptoms in the left leg resulting from compression of the left common iliac vein (CIV) between the right common iliac artery (anteriorly) and the vertebral body of the fifth lumbar vertebra (posteriorly).² This anatomic variation is associated with the onset of symptomatic acute deep vein thrombosis (DVT) of the left leg.³ Diagnosing and treating MTS is therefore important to prevent multiple DVT and ultimately post-thrombotic syndrome (PTS).⁴

The standard classical treatment strategy for DVT is medical treatment with anticoagulant agents, the aim of which is to prevent the lethal complication of pulmonary embolism (PE) and recurrent DVT.⁵ Anticoagulants are employed to prevent thrombosis progression rather than to remove the thrombosis. With the advent of minimally invasive surgery, endovascular treatments including catheter-direct thrombolysis (CDT) and stent placement have been applied to the treatment of MTS and DVT.^{4,6} Although thrombolysis increases the patency of veins and reduces the

incidence of PTS, bleeding complications limit the treatment's applicability.⁵

AngioJet™ rheolytic thrombectomy combines thrombolytic drugs and mechanical thrombectomy, thereby reducing the dose of thrombolytic agents and the risk of bleeding. This study was performed to assess the clinical outcome of the combination of AngioJet™ rheolytic thrombectomy and stenting for the treatment of MTS-related DVT.

Materials and methods

Patients and study design

This retrospective cohort study was approved by the institutional review board of Chang Gung Memorial Hospital in Taoyuan, Taiwan (Approval No. 202001575B0). Because this was a retrospective cohort study, the need for individual informed consent was waived. The reporting of this study conforms to the STROBE guidelines.⁷

We reviewed the electronic medical records, medical history, imaging findings, and laboratory data of consecutive patients with leg DVT treated with AngioJet™ rheolytic thrombectomy at our center from January 2017 to June 2020. All patient

details were de-identified during data collection. We employed the ZelanteDVT™ catheter (AngioJet™ venous catheter) for the venous procedures in accordance with the manufacturer's instructions. We confirmed the diagnosis of leg DVT by the clinical signs and symptoms and the duplex ultrasound or computed tomographic venography (CTV) images. The diagnostic criteria for MTS-related DVT were as follows: (1) >50% compression of the left CIV by the right common iliac artery and fifth lumbar vertebral body in the transverse view of computed tomography (Figure 1); (2) accumulation of thrombus burden from the distal part of the left leg (including the popliteal vein, superficial femoral vein, common femoral vein, external iliac vein, and CIV) to the impinged vein area (Figure 2); (3) multiplanar venography after AngioJet™ rheolytic thrombectomy showing a stenotic lesion at the MTS-impinged vein and focal left CIV stenosis with the collateral vein; and (4) balloon

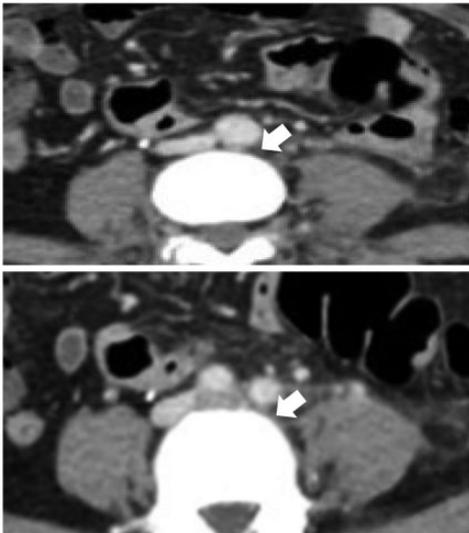


Figure 1. Fifty percent compression of the left common iliac vein by the right common iliac artery and fifth lumbar vertebral body in the transverse view of computed tomography (arrow).

waist noted in pre-dilation angioplasty before stenting under fluoroscopy during the procedure.

Procedure

All procedures were performed with the involvement of at least one vascular surgeon and one interventional radiologist. The patient's position during the operation and the access site were chosen by the operators according to the preoperative CTV images.

Inferior vena cava filter

The operators decided whether to implant a retrievable inferior vena cava (IVC) filter based on the risk of dislodging massive thrombi from the DVT of the iliofemoral vein, resulting in PE. Vascular access for IVC filter implantation was from the right internal jugular vein or patent contralateral common femoral vein under real-time echo-guided venipuncture. During the IVC filter implantation, all patients were positioned supine under local anesthesia.



Figure 2. Accumulation of thrombus burden in the left iliac vein (arrowhead).

AngioJetTM rheolytic thrombectomy

The ipsilateral leg vein was punctured under ultrasound guidance (BD/Bard Site Rite 5; BD/Bard, Franklin Lakes, NJ, USA). Following venous access with an 8-French sheath in place, we first performed pre-procedure venography to evaluate the degree of thrombus and the burden of the left leg. An 8-French AngioJetTM DVT thrombectomy infusion catheter (ZelanteDVTTM catheter; Boston Scientific, Marlborough, MA, USA) was inserted using an over-the-wire technique into the most proximal part of the thrombus. We then infused the diluted thrombolytic agent urokinase (250,000 U) (Green Cross Corporation Co., Ltd., Gyeonggi-do, Korea) under the power-pulsed mode of the AngioJetTM catheter to deliver the drug directly and evenly into the thrombus if there were no absolute or relative contraindications. We then waited for 15 to 20 minutes to allow the thrombolytic agent to work. We performed percutaneous mechanical thrombectomy (PMT) using the thrombectomy mode of the AngioJetTM from the most proximal part of the thrombus in the CIV to the distal part of the thrombus. Venography was performed through an introducer sheath or an AngioJetTM rheolytic thrombectomy catheter. If the venography revealed residual thrombi, we repeated the AngioJetTM rheolytic thrombectomy procedure, focusing on the residual thrombi until all retrievable thrombi were removed or the recommended PMT duration had elapsed (≤ 480 s) in accordance with the manufacturer's instructions for use.

Stenting

After AngioJetTM rheolytic thrombectomy, we confirmed the MTS anatomical stenotic lesion using intraoperative multiplanar venography. The exact location of the MTS anatomical stenotic lesion was

identified by the balloon waist during the pre-dilatation angioplasty (Figure 3(b)). We chose the appropriate stent size according to the size of the healthy veins proximal and distal to the lesions. We deployed the self-expanding stent with proximal extension into the IVC without touching the contralateral side of the IVC wall to sufficiently cover the stenotic lesion and not compromise the venous outflow in the contralateral leg (Figure 3(c)). The distal end of the stent was extended at least 1 cm from the healthy venous landing zone distal to the MTS stenotic lesion (Figure 3(d)). The stents available at our center are the WallstentTM (Boston Scientific) and the VenovoTM venous stent (BD/Bard), and they were selected at the physician's discretion.

After the procedure, the introducer sheath was removed and the vascular access wound was sutured with 4-0 monofilament nonabsorbable Prolene sutures or was simply manually compressed until total hemostasis was achieved.

Postoperative care

After the operation, the patients were prescribed low-molecular-weight heparin or novel oral anticoagulants immediately after the procedure, and sufficient intravenous hydration was ensured. The patients were encouraged to ambulate 2 hours after the procedure and wear grade II compressive stockings as early as possible. After discharge, the patients were prescribed novel oral anticoagulants and the heparin was discontinued.

Follow-up

The clinical condition of the affected limb was evaluated at 1, 3, 5, and 12 months post-operatively. The patients thereafter made yearly visits to the vascular surgeons' or interventional radiologists' follow-up clinics, where the stents were examined under

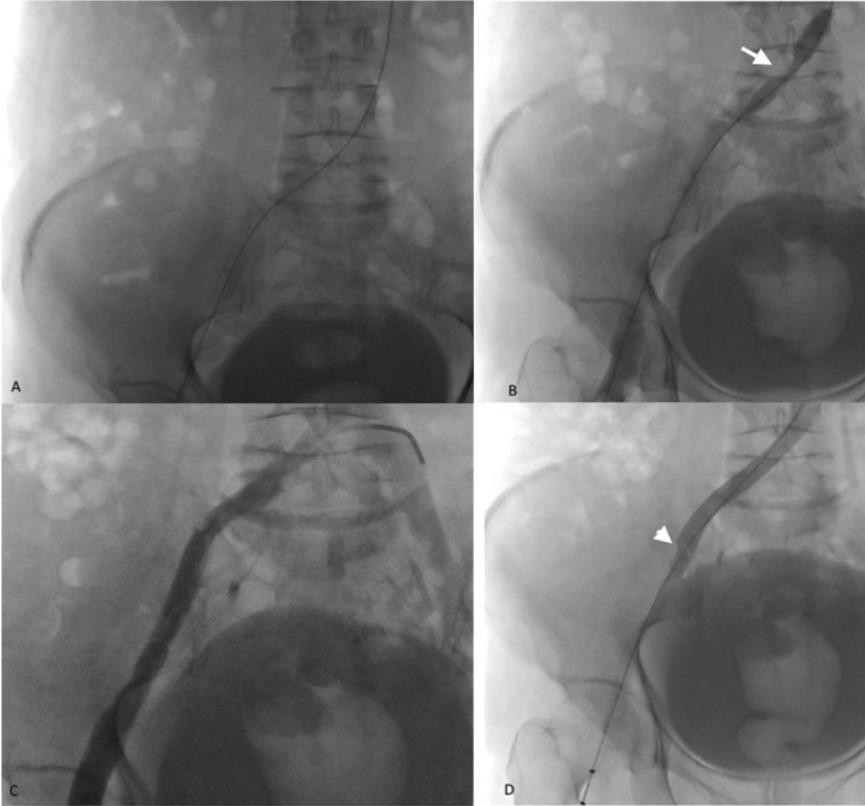


Figure 3. (a) A 0.035-inch guidewire (0.035 Radiofocus® Guidewire M; Terumo Corp., Somerset, NJ, USA) was advanced to the inferior vena cava. (b) The exact position of the May–Thurner syndrome-related anatomical stenotic lesion was identified by the balloon waist during pre-dilatation angioplasty. (c) A self-expanding stent was deployed with proximal extension into the inferior vena cava without touching the contralateral side of the inferior vena cava wall to sufficiently cover the stenotic lesion and not compromise the venous outflow in the contralateral leg and (d) The distal end of the stent was extended at least 1 cm into the healthy normal venous landing zone distal to the May–Thurner syndrome-related stenotic lesion.

duplex ultrasound or computed tomography. The clinical condition of the leg was evaluated and recorded in the electronic medical record as no improvement or improvement, based on the patient’s feedback.

Statistical analysis

Data were collected using Microsoft Excel (Microsoft Corp., Redmond, WA, USA), and all analyses were conducted using IBM SPSS Statistics for Windows, Version

25.0 (IBM Corp., Armonk, NY, USA). Descriptive data are expressed as median (interquartile range (IQR)) for continuous variables, and categorical variables are expressed as numbers. The primary patency of the stent in the affected vein was calculated using the Kaplan–Meier method.

Results

During the study period, 14 patients underwent AngioJet™ rheolytic thrombectomy

to treat MTS-related DVT (9 women and 5 men). Table 1 shows the patients' demographics. The patients' median age was 58 years (IQR, 50–76 years). Their underlying diseases included hypertension in four patients, malignancy in four, diabetes mellitus in three, smoking in two, peripheral artery disease in one, stroke in one, dyslipidemia in one, and chronic obstructive pulmonary disease in one.

The median DVT onset time was 8 days (IQR, 3–21 days), and four patients developed subacute DVT (≥ 21 days). The first four patients underwent implantation of an IVC filter before the AngioJet™ rheolytic thrombectomy. Two patients had organized thrombi in the superficial femoral vein and underwent adjuvant percutaneous transluminal angioplasty for thrombi maceration. The median procedure time was 130 minutes (IQR, 91–189 minutes).

The median hospital stay was 7 days (IQR, 5–26 days). Patient 1 had residual thrombi and an occluded iliac stent and underwent adjuvant CDT for revascularization

during hospitalization. The stent was patent after the re-intervention. The primary patency rate for the iliac stents was 92.9% at 12 months.

Three IVC filters were removed before discharge, and no thrombi were captured in the IVC filter net (as observed by venography) during the IVC retrieval procedure. Patient 3 underwent filter removal 5 months after the operation because of residual thrombi after iliac stenting. Because the stent was patent and the patient had no signs or symptoms, no further intervention was performed. No patients developed major or minor bleeding, and none presented signs or symptoms of PE during or after the procedures.

Discussion

DVT is a common but elusive venous disease that can lead to lethal complications such as PE.⁸ According to the guidelines of the European Society of Cardiology, anticoagulant medical treatment is an

Table 1. Demographic data, clinical findings, and clinical outcomes of patients with MTS-related DVT.

Patient	Age (years)	Sex	Underlying disease	DVT onset time (days)	IVC filter	Position	Access
1	48	M	PAD, smoker	30	Yes	Supine	LPTV
2	83	M	HTN, COPD	9	Yes	Prone	LPopV
3	61	M	Dyslipidemia, smoker	14	Yes	Prone	LPopV
4	64	F	HTN, DM	6	Yes	Supine	RCFV
5	79	F	DM	3	–	Prone	LPopV
6	41	F	DM, right lower limb DVT	21	–	Prone	LPopV
7	65	F	Ovarian cancer, HTN	10	–	Prone	LPopV
8	58	F	Ovarian cancer	4	–	Prone	LPopV
9	86	F	HTN	3	–	Prone	LPopV
10	46	F	Kidney donor	1	–	Prone	LPopV
11	43	M	–	21	–	Prone	LPopV
12	57	M	Stroke	3	–	Prone	LPopV
13	76	F	Sigmoid cancer	30	–	Prone	LPopV
14	58	F	Endometrial cancer with metastasis	1	–	Prone	LPopV, RSSV

MTS, May–Thurner syndrome; DVT, deep vein thrombosis; IVC, inferior vena cava; M, male; F, female; PAD, peripheral artery disease; DM, diabetes mellitus; HTN, hypertension; COPD, chronic obstructive pulmonary disease; LPTV, left posterior tibial vein; LPopV, left popliteal vein; RCFV, right common femoral vein; RSSV, right small saphenous vein.

Table I. Continued.

Patient	Stent	Stent size	Adjuvant procedure	Procedure time (minutes)	Hospitalization (days)	Follow-up (months)	Outcome
1	Wallstent	14 × 9	CDT	256	15	30	*Occluded
2	Wallstent	14 × 9 + 14 × 6		71	49	29	Patent
3	Wallstent	14 × 9		214	2	26	#Patent
4	Wallstent	12 × 9		152	7	20	Patent
5	Wallstent	12 × 6		81	6	20	Patent
6	Wallstent	14 × 9 + 14 × 6 + 12 × 6		180	20	19	Patent
7	Wallstent	14 × 6		95	45	16	Patent
8	Wallstent	16 × 9		138	25	15	Patent
9	Wallstent	16 × 9	Ballooning for SFV (Conquest 8 × 4)	79	6	14	Patent
10	Venovo	14 × 9 + 12 × 9		96	4	12	Patent
11	Venovo	16 × 10 + 12 × 10	Ballooning for SFV (Conquest 8 × 4)	122	3	11	Patent
12	Venovo	14 × 8		94	7	10	Patent
13	Wallstent	9 × 12		264	5	4	Patent
14	Wallstent	16 × 9		137	28	2	Patent

*The stent was occluded on postoperative day 2. CDT was performed for revascularization.

#A residual thrombus was found in the iliac vein, but the stent was patent.

CDT, catheter-directed thrombolysis; SFV, superficial femoral vein.

option for either initial or long-term treatment if there are no contraindications.⁹ Despite adequate anticoagulation therapy after DVT, however, 20% to 50% of patients develop PTS,^{10,11} which is incurable and associated with a significantly impaired quality of life.¹²

According to a study by Alesh et al.,¹³ early thrombus removal by CDT is beneficial in decreasing the risk of PTS and bleeding complications compared with systemic thrombolysis in treating DVT. However, bleeding complications are still the major concern in CDT.⁵

By employing Bernoulli's principle, the AngioJetTM rheolytic thrombectomy device actively removes and suctions fragmented thrombi using power-pulse thrombolysis via a small catheter. The device is an alternative advanced modality that can decrease the dosage of thrombolytic agents and reduce the risk of major bleeding complications inherent in CDT.¹⁴

In this study, we applied AngioJetTM rheolytic thrombectomy to successfully treat MTS-related DVT without bleeding complications. By performing urokinase injection with the power-pulse mode of the AngioJetTM, we were able to successfully remove subacute thrombi from four patients. Only one patient (our first case) required a further adjuvant CDT procedure because of the relatively long thrombosis duration and our lack of familiarity with the procedure at that time.

According to Virchow's triad, a major theory delineating the pathogenesis of venous thromboembolism, the disease will occur as a result of blood stasis. MTS is an uncommon anatomic variation that results from overcompression of the left CIV between the vertebral body of the fifth lumbar vertebra and the overlying right common iliac artery. Alternating blood flow in the left CIV in patients with MTS will induce recurrent DVT. However, MTS

has been underestimated in the past and should always be suspected in the left leg of patients with DVT.¹⁵ In patients with MTS-related DVT, it is essential to correct the underlying anatomic variation that can lead to the onset of DVT, thereby preventing DVT recurrence.

The current mainstream treatment for MTS after iliofemoral thrombi removal is endovascular treatment. The Active Stenting for May–Thurner Iliac Compression Syndrome registry reported the results of stent patency in 59 patients with MTS, with a primary patency rate of 84% at 19 months.¹⁶ Goldman et al.¹⁷ retrospectively reviewed 10 cases of stenting for MTS and found a 79% primary patency rate and 100% secondary patency rate at 12 months. Hager et al.¹⁸ performed a retrospective review and analysis of 77 patients who underwent stenting for MTS and reported a 91% primary patency rate at 36 months. Several researchers have reported the results of PMT plus stenting in patients with acute iliofemoral DVT caused by MTS.^{19,20} Jiang et al.²⁰ reported a primary patency rate of 91.1% at 24 months. In the present study, we employed the AngioJet™ rheolytic thrombectomy device for thrombus removal and treated the MTS lesions concomitantly. The primary patency rate at 12 months was 92.9%, which is consistent with that of prior studies. No stent migration, fracture, or collapse was detected during follow-up, and none of our patients developed recurrent DVT.

The foundation of successful stenting is adequate assessment of the landing zones. Intravascular ultrasound provides important information using a small ultrasound probe with no risk of contrast medium-related nephropathy, allergy, or radiation exposure compared with venography.⁴ However, intravascular ultrasound is not available at our center. We therefore assessed the MTS and landing zones for the stent through preoperative CTV and

intraoperative multiplanar venography. In the preoperative CTV images, the left CIV was compressed between the right common iliac artery and the fifth lumbar vertebral body in the transverse view, and extensive distal iliofemoral thrombi were present. Intraoperative multiplanar venography showed that the stenotic MTS lesions had multiple collateral veins that were more proximal to the vein. By combining the CTV and multiplanar venography images, we were able to place the stent in such a manner as to precisely cover the lesion without touching the contralateral wall of the IVC and interfering with the right CIV flow.

To prevent stent collapse and migration, we did not place the stent exactly at the ilio caval confluence. The limitation of the current stent design is that the radial force of the bilateral stent edges is relatively weaker than that of the body. Prior studies have therefore recommended placing the stent so that it protrudes into the IVC.^{21,22} In a study by Khairy et al.,²³ all the patients developed contralateral limb DVT following ipsilateral iliac stenting, which occurred only with complete coverage of the contralateral CIV. Our strategy for MTS stenting was therefore to stent the iliac with cava extension without touching the contralateral wall of the IVC to maintain bilateral CIV flow.

In the present study, we implanted IVC filters in the first four patients only to prevent PE. IVC filter implantation before CDT or PMT for acute iliofemoral DVT has been suggested for certain patients, such as those with preoperative clinical PE, those with multiple DVT risk factors, and women.²⁴ Considering its pathophysiology, MTS is characterized by chronic iliac artery pulsation that stimulates the underlying iliac vein's interior vessel wall, producing "spur"-like tissue formation and then partially or totally obstructing the venous outflow, ultimately resulting in

venous thrombosis. The MTS-related stenotic lesion acts as a natural barrier/filter in the venous lumen, and its narrow lumen induces venous thrombosis and indirectly prevents the bulky thrombus from accidentally dislodging from the iliofemoral vein into the pulmonary artery. Jin et al.²⁵ found that patients with acute DVT and MTS were at lower risk of PE than were patients with acute DVT without MTS. However, the IVC filter was also a risk factor for contralateral limb DVT.²³ We changed our protocol so that the IVC filter was not routinely implanted before the AngioJetTM rheolytic thrombectomy.

The limitations of this study are its small sample size; its single-arm, nonrandomized, retrospective nature; and its limited follow-up time. Further studies with larger populations and longer follow-up periods are warranted to determine the patency of ilio-caval stents and the safety of AngioJetTM rheolytic thrombectomy in treating MTS-related DVT.

Conclusions

Although the present study has certain limitations, it has shown that our strategy of employing AngioJetTM rheolytic thrombectomy and stenting of MTS lesions without concomitant coverage of the contralateral CIV may be beneficial for patients with MTS-related DVT.

Author contributions

Conceptualization: Po-Jen Ko, Sheng-Yueh Yu, and Chun-Hui Lee. Data curation: Chun-Hsien Hsin and Hsuan-Tzu Yang. Investigation: Ta-Wei Su, I-Hao Su, and Sung-Yu Chu. Methodology: Sung-Yu Chu, Po-Jen Ko, and Sheng-Yueh Yu. Supervision: Po-Jen Ko, Sheng-Yueh Yu, and Chun-Hui Lee. Writing – original draft: Wen-Cheng Wei and Chun-Hsien Hsin. Writing – review and editing: Sheng-Yueh Yu and Chun-Hui Lee.

Declaration of conflicting interests

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References

1. May R, Thurner J. The cause of the predominantly sinistral occurrence of thrombosis of the pelvic veins. *Angiology* 1957; 8: 419–427.
2. Kaltenmeier CT, Erben Y, Indes J, et al. Systematic review of May-Thurner syndrome with emphasis on gender differences. *J Vasc Surg Venous Lymphat Disord* 2018; 6: 399–407.e4.
3. Kibbe MR, Ujiki M, Goodwin AL, et al. Iliac vein compression in an asymptomatic patient population. *J Vasc Surg* 2004; 39: 937–943.
4. Knuttinen MG, Naidu S, Oklu R, et al. May-Thurner: diagnosis and endovascular management. *Cardiovasc Diagn Ther* 2017; 7: S159–S164.
5. Watson L, Broderick C and Armon MP. Thrombolysis for acute deep vein thrombosis. *Cochrane Database Syst Rev* 2016; 11: CD002783.
6. Sang HF, Li JH, Du XL, et al. Diagnosis and endovascular treatment of iliac venous compression syndrome. *Phlebology* 2019; 34: 40–51.
7. Von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Ann Intern Med* 2007; 147: 573–577.
8. Hirsh J and Hoak J. Management of deep vein thrombosis and pulmonary embolism. A statement for healthcare professionals. Council on Thrombosis (in consultation with the Council on Cardiovascular

- Radiology), American Heart Association. *Circulation* 1996; 93: 2212–2245.
9. Mazzolai L, Aboyans V, Ageno W, et al. Diagnosis and management of acute deep vein thrombosis: a joint consensus document from the European Society of Cardiology working groups of aorta and peripheral vascular diseases and pulmonary circulation and right ventricular function. *Eur Heart J* 2018; 39: 4208–4218.
 10. Kahn SR, Shrier I, Julian JA, et al. Determinants and time course of the post-thrombotic syndrome after acute deep venous thrombosis. *Ann Intern Med* 2008; 149: 698–707.
 11. Kahn SR, Galanaud JP, Vedantham S, et al. Guidance for the prevention and treatment of the post-thrombotic syndrome. *J Thromb Thrombolysis* 2016; 41: 144–153.
 12. Wik HS, Eenden TR, Ghanima W, et al. Diagnostic scales for the post-thrombotic syndrome. *Thromb Res* 2018; 164: 110–115.
 13. Alesh I, Kayali F and Stein PD. Catheter-directed thrombolysis (intrathrombus injection) in treatment of deep venous thrombosis: a systematic review. *Catheter Cardiovasc Interv* 2007; 70: 143–148.
 14. Zack CJ, Alkhouli M and Bashir R. Catheter-directed thrombolysis: is it worth the risk? *Lancet Haematol* 2016; 3: e54–e55.
 15. Mousa AY and AbuRahma AF. May-Thurner syndrome: update and review. *Ann Vasc Surg* 2013; 27: 984–995.
 16. Funatsu A, Anzai H, Komiyama K, et al. Stent implantation for May-Thurner syndrome with acute deep venous thrombosis: acute and long-term results from the ATOMIC (AcTive stenting for May-Thurner Iliac Compression syndrome) registry. *Cardiovasc Interv Ther* 2019; 34: 131–138.
 17. Goldman RE, Arendt VA, Kothary N, et al. Endovascular management of May-Thurner syndrome in adolescents: a single-center experience. *J Vasc Interv Radiol* 2017; 28: 71–77.
 18. Hager ES, Yuo T, Tahara R, et al. Outcomes of endovascular intervention for May-Thurner syndrome. *J Vasc Surg Venous Lymphat Disord* 2013; 1: 270–275.
 19. Lopez R, DeMartino R, Fleming M, et al. Aspiration thrombectomy for acute iliofemoral or central deep venous thrombosis. *J Vasc Surg Venous Lymphat Disord* 2019; 7: 162–168.
 20. Jiang C, Zhao Y, Wang X, et al. Midterm outcome of pharmacomechanical catheter-directed thrombolysis combined with stenting for treatment of iliac vein compression syndrome with acute iliofemoral deep venous thrombosis. *J Vasc Surg Venous Lymphat Disord* 2020; 8: 24–30.
 21. Raju S, McAllister S and Neglen P. Recanalization of totally occluded iliac and adjacent venous segments. *J Vasc Surg* 2002; 36: 903–911.
 22. Neglén P and Raju S. Balloon dilation and stenting of chronic iliac vein obstruction: technical aspects and early clinical outcome. *J Endovasc Ther* 2000; 7: 79–91.
 23. Khairy SA, Neves RJ, Hartung O, et al. Factors associated with contralateral deep venous thrombosis after ilio caval venous stenting. *Eur J Vasc Endovasc Surg* 2017; 54: 745–751.
 24. Avgerinos ED, Hager ES, Jeyabalan G, et al. Inferior vena cava filter placement during thrombolysis for acute iliofemoral deep venous thrombosis. *J Vasc Surg Venous Lymphat Disord* 2014; 2: 274–281.
 25. Jin S, Sun Z, Li X, et al. May-Thurner syndrome and the risk of pulmonary embolism in patients with acute deep venous thrombosis. *J Vasc Surg Venous Lymphat Disord* 2018; 6: 433–440.e1.