Original Article

Risk factors for stent occlusion after catheter-directed thrombolysis and iliac vein stenting in the treatment of May-Thurner syndrome with iliofemoral deep vein thrombosis: a retrospective cohort study

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Background: This study aimed to identify the risk factors for stent occlusion in patients with iliofemoral deep vein thrombosis (DVT) secondary to May-Thurner syndrome (MTS) who underwent catheter-directed thrombolysis (CDT) and iliac vein stenting.

Methods: A retrospective analysis was performed on 44 patients who underwent CDT and iliac vein stenting for MTS with iliofemoral DVT between October 2001 and March 2018. MTS was diagnosed based on extrinsic compression of the left common iliac vein (CIV) by the overlying right common iliac artery (CIA) on computed tomography (CT). Clinical records of the study population were reviewed to collect baseline data, procedural characteristics, and outcomes. Final venograms showing diffuse and irregular wall thickening in the iliofemoral vein were considered to indicate a chronic post-thrombotic lesion. The stent position was categorized as follows: confluence coverage without touching the contralateral inferior vena cava (IVC) wall, IVC extension contacting the contralateral IVC wall, or distal to the iliocaval junction. Stent patency was assessed using duplex ultrasonography. Risk factors for stent occlusion were assessed using univariate and multivariate Cox proportional hazard models.

Results: The median duplex ultrasound follow-up period was 25 months (range, 1–196 months). The overall cumulative patency rate at 12 months was 70.0%. In the univariate Cox regression, factors significantly associated with stent occlusion included symptom duration >2 weeks before CDT, partial thrombolysis (50–99% of thrombus removal), chronic post-thrombotic lesions, and stent position. Multivariate Cox regression showed that chronic post-thrombotic lesions [hazard ratio (HR) =7.15; 95% confidence interval (CI): 1.32–38.81; P=0.023] and a stent distal to the iliocaval junction (HR =5.59; 95% CI: 1.46–21.38; P=0.012) were significantly associated with stent occlusion.

Conclusions: Chronic post-thrombotic lesion and a stent distal to the iliocaval junction were important risk factors for stent occlusion in patients who underwent CDT and iliac vein stenting.

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Keywords: Deep vein thrombosis (DVT); May-Thurner syndrome (MTS); catheter-directed thrombolysis (CDT); iliac vein stenting; stent occlusion

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Introduction

May-Thurner syndrome (MTS) is a condition that results from the compression of the left common iliac vein (CIV) between the right common iliac artery (CIA) and lumbar vertebra (1). MTS is a major cause of deep vein thrombosis (DVT) and chronic venous insufficiency (2,3). In clinical practice, the extent of iliac vein compression has been inconsistent with symptomatic lower-extremity venous disorder (4,5). According to a recent study, hemodynamics such as collateral vessels and decreased flow rate as well as iliac vein stenosis were significantly associated with lower limb symptom severity (6). Stent insertion for venous outflow obstruction is a safe and effective method for improving venous outflow, increasing patency, and reducing post-thrombotic syndrome (7-9). For cases of DVT secondary to MTS, treatment of underlying stenosis with iliac vein stenting has been reported to show better clinical outcomes than catheter-directed thrombolysis (CDT) alone (10,11).

Chronic total occlusion of the native vein, stent extension into the common femoral vein, and post-thrombotic etiology have been identified as the factors associated with stent patency in previous studies (12-14). According to recently reported studies, larger stent diameter and antiplatelet therapy were associated with improved stent patency, whereas multiple stents and irregular compression stocking wearing were predictors of in-stent obstruction (15-17). In addition, the relationship between stenting across the inguinal ligament and stent patency is still controversial (18-20). Another study on iliocaval stenting found no clear effect of the duration of anticoagulant and antiplatelet treatment on the patency of venous stents (15). There is a wide divergence in the risk factors for stent occlusion, which is most likely due to bias from the selected patients or treatment method. Moreover, only few studies have investigated the risk factors for stent occlusion in patients who have undergone iliac vein stenting after acute DVT and have reported suboptimal thrombolysis (≤50%) as a predictor of stent occlusion (21). In this study, we evaluated technical aspects and venographic findings to predict stent occlusion. Our study aimed to identify the risk factors for stent occlusion in patients with iliofemoral DVT secondary to MTS who underwent CDT and iliac vein stenting. We present the following article in accordance with the STROBE reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-22-515/rc).

Methods

Patients

From October 2001 to March 2018, 54 consecutive patients were diagnosed with first-episode iliofemoral DVT and treated with CDT and iliac vein stenting in our hospital. The initial diagnosis of DVT was made in all patients with venous duplex ultrasound. MTS was diagnosed based on extrinsic compression of the left CIV by the overlying right CIA on computed tomography (CT) combined with extensive downstream venous thrombosis. Stenosis greater than 50% of the venous luminal diameter was considered as an indicator of left CIV compression (6). Exclusion criteria were as the follows: (I) patients who underwent right iliac vein stenting (n=5); (II) absence of preprocedural CT images (n=2); (III) bilateral DVT involvement (n=1); and (IV) patients without any follow-up imaging (n=2). Finally, a total of 44 patients were included in this retrospective cohort study (*Figure 1*). We evaluated the demographics (including age, sex, height, body mass index, and associated comorbidities), underlying risk factors for venous thrombosis, symptom duration, procedural characteristics, and follow-up findings via review of medical records. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The present study was approved by the Institutional Review Board of Samsung Medical Center. The requirement for written informed consent was waived due to the retrospective nature of the study.

Procedure

Anticoagulation treatment with low-molecular-weight heparin (enoxaparin 40–60 mg) was initiated on the day of

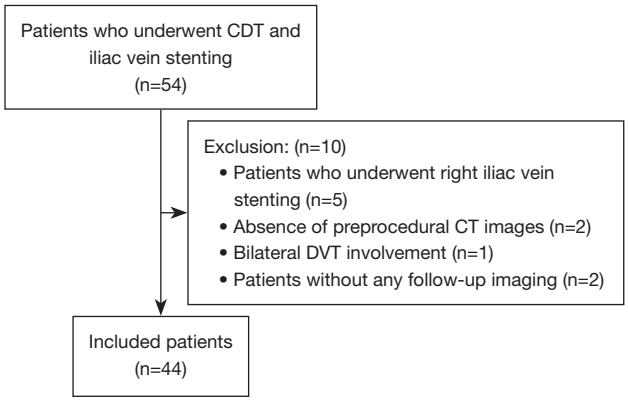

Figure 1 Flowchart of patient selection. CDT, catheter-directed thrombolysis; CT, computed tomography; DVT, deep vein thrombosis.

diagnosis. CDT was initiated on the first following working day. A bolus dose of 3,000–5,000 IU unfractionated heparin was administered at the start of the procedure, followed by an infusion of unfractionated heparin (15 U/kg/h) that was adjusted to maintain a 1.2–1.7-fold longer activated partial thromboplastin time, i.e., 40–60 s.

Percutaneous access was obtained under ultrasound guidance through the popliteal vein in 43 patients. In one case, an antegrade approach through the popliteal vein was initially attempted. However, it failed to pass through the iliocaval junction with a guidewire, and therefore a retrograde approach through the right internal jugular vein was selected. Before CDT, a retrievable inferior vena cava (IVC) filter was placed if a free floating thrombus was present in the infrarenal IVC (n=9). To evaluate the degree of thrombus, ascending venography was obtained by placing a 7–12-Fr vascular sheath. A multiple-side-hole infusion catheter (Cook, Bloomington, IN, USA) was placed in the thrombotic segments, and catheter-directed infusion of urokinase was established. The urokinase was given at a maximum dose of 500,000 U as a bolus or a maximum rate of 120,000 U/h as a continuous infusion. During the procedure, heparin was infused through the sheath. The thrombolytic agent was administered until complete lysis or no further improvement, and the total infusion time was not to exceed 72 hours. Most patients (n=41; 93.2%) underwent additional aspiration thrombectomy with a 6–8-Fr guiding catheter [Envoy (Cordis) or Shuttle-SL Flexor (Cook)] connected to a 50 mL syringe. After thrombolysis and/or thrombectomy, the degree of iliac vein stenosis and the stenotic segment was evaluated using venography. Adjunctive endovascular treatments, including balloon angioplasty and stent placement, were performed to correct stenosis of the left iliac vein. Stent diameter was oversized 10–20% compared to the normal patent iliac vein. Typically, stent diameters ranged from 12 to 16 mm in CIV lesions and 10 to 14 mm in external iliac vein lesions. Immediate post-procedure venography was performed in all patients. For patients with IVC filter insertion, the filter was removed within 1 month.

Definitions

All venographic images were analyzed according to the consensus of the two interventional radiologists (HSP and MSK, with more than 5 years of experience each). The location of the left CIV stent was evaluated using the final venogram and classified into one of following three groups: Category 1, covering the iliocaval confluence without touching the contralateral IVC wall; Category 2, extending up to the IVC, contacting the contralateral IVC wall; and Category 3, distal to the iliocaval junction and not covering the confluence (*Figure 2*). When it was difficult to visualize iliocaval bifurcation on the final venogram, the location of iliocaval confluence was determined by referring to the venous angle between the left CIV and IVC on the final venogram and the location of the confluence on the preprocedure CT.

Technical success was defined as successful restoration of antegrade in-line flow in the treated vein with elimination of any underlying obstructive lesion (22). The degree of thrombolysis was classified as complete (grade III, 100% thrombus removal), partial (grade II, 50–99% of thrombus removal), and minimal or no thrombolysis (grade I, <50% thrombus removal) using the Venous Registry Index score as assessed on the final venogram (22,23). The final venogram showing diffuse and irregular wall thickening in the iliofemoral vein was considered a chronic post-thrombotic lesion (24).

Follow-up

After completion of endovascular therapy, all patients received anticoagulation therapy with warfarin or rivaroxaban without the addition of antiplatelet agents. The minimum duration of anticoagulation therapy was 6 months. Duplex ultrasound examination was performed at 2 weeks, 1, 3, 6, and 12 months and then annually after the intervention. Stent patency was defined as the presence of

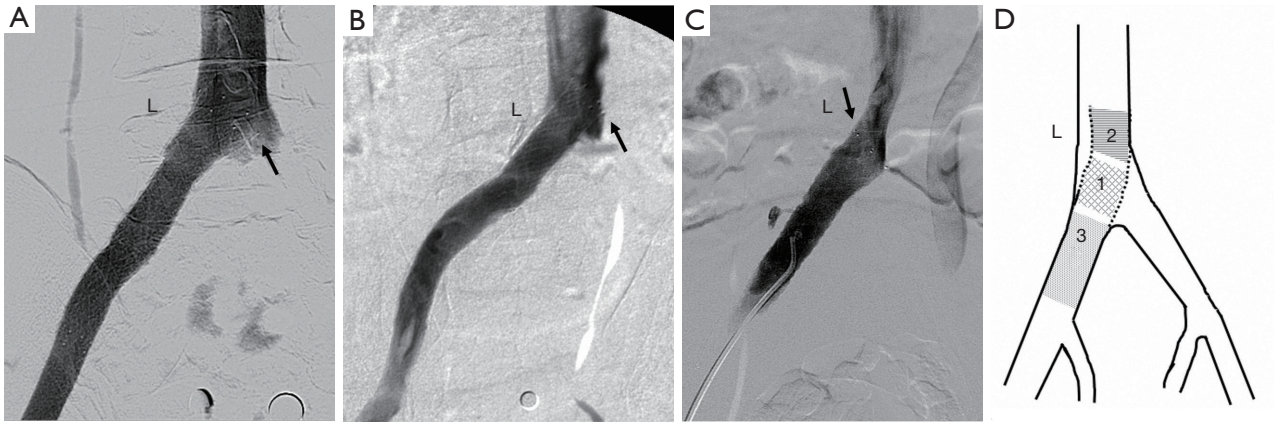

Figure 2 Categorization of the left iliac vein stent position on venogram in prone position: (A) Category 1, covering the iliocaval confluence without touching the contralateral IVC wall; (B) Category 2, extending to the IVC, contacting the contralateral IVC wall; and (C) Category 3, distal to the iliocaval junction and not covering the confluence. Arrows indicate tips of stents. (D) A diagram illustrating the three categories, respectively. L, left side; IVC, inferior vena cava.

antegrade flow in the stents.

Statistical analysis

Numerical values are presented as medians (min–max), and categorical variables are summarized as frequencies (percentages). Cumulative stent patency rates were calculated using Kaplan-Meier survival tables. Univariate and multivariate Cox regression models were constructed to identify the factors associated with stent occlusion. All computations were performed using SPSS software (version 18.0; SPSS, Chicago, IL, USA), and P values less than 0.05 were considered statistically significant.

Results

Baseline characteristics

Baseline characteristics, procedural characteristics, and outcomes are summarized in *Table 1*. The median age of all patients was 51 years (range, 23–69 years), and 22 patients (50%) were women. The median symptom duration was 7 days (range, 2–30 days). Ten patients (22.7%) had subacute symptoms (i.e., >14 days). Thirty-eight out of 44 patients underwent hypercoagulable work-up, including levels of protein C and protein S, factor V, factor II, lupus anticoagulant, anti-cardiolipin immunoglobulin, homocysteine, and anti-thrombin III. Five patients (11.4%) had thrombophilia (2 patients with lupus anticoagulant, 1 patient with protein C deficiency, 1 patient with protein S deficiency, and 1 patient with anti-cardiolipin antibodies). Two patients had active bladder cancer.

Procedural characteristics

All patients were taken to the angiography suite within a median of 17 hours (range, 5–96 hours) after initial presentation. The median total urokinase dose was 2.20×10^6 IU with a range of 0.40×10^6–6.73×10^6 IU. The median duration of CDT was 19 h (range, 3–72 h). Stent placement was performed using self-expandable Smart stent (Cordis, Miami, FL, USA; n=37), Wallstent (Schneider, Boston Scientific; n=2), and Protege EverFlex (EV3, Minneapolis, MN, USA; n=1), or balloon-expandable Palmaz stent (Cordis, Warren, NJ, USA; n=4). All stents were placed above the inguinal ligament. Two or more stents were used in 12 (27.3%) patients, and the median stent diameter was 14 mm (range, 10–16 mm). The iliac stent covered the iliocaval confluence without touching the contralateral IVC wall in 28 (63.6%) patients, extended to the contralateral IVC wall in 9 (20.5%) patients, and was located distal to the iliocaval junction in 7 (15.9%) patients. On the final venogram, complete thrombus removal was observed in 59.1% (26/44), and partial thrombus removal was observed in 40.9% (18/44). There was no procedure with less than 50% thrombus removal, and all patients successfully restored antegrade flow in the treated vein after the procedure. Chronic post-thrombotic lesions were detected in 7 patients (15.9%). Four of these had diffuse and

Table 1 Baseline characteristics, procedural characteristics, and outcomes in the study population (n=44)

Variables	Observed values
Baseline	
Age (years)	51 [23–69]
Female sex	22 (50.0)
Height (cm)	167.6 [150.1–183]
Body mass index (kg/m^2)	25.0 [16.7–35.7]
Symptoms for >2 weeks prior to stenting	10 (22.7)
Risk factors for venous thrombosis	
Surgery within 3 months	6 (13.6)
Thrombophilia	5 (11.4)
Oral contraceptive	4 (9.1)
Malignancy	2 (4.5)
Immobilization	2 (4.5)
Cardiopulmonary disease	2 (4.5)
Idiopathic	24 (54.5)
Associated comorbidities	
Hypertension	4 (9.1)
Dyslipidemia	2 (4.5)
Diabetes mellitus	3 (6.8)
Active smokers	6 (13.6)
Thrombus, involved vein segments	
Iliac (CIV and EIV)	44 (100.0)
Femoral (CFV and FV)	42 (95.5)
Popliteal vein	34 (77.3)
Calf veins	30 (68.2)
Procedural characteristics	
Aspiration thrombectomy	41 (93.2)
IVC filter insertion	9 (20.5)
Total urokinase dose (IU)	2.20×10^6 [0.40×10^6–6.73×10^6]
Post-procedure venography findings	
Chronic post-thrombotic lesions	7 (15.9)
Thrombolysis grade	
Complete thrombolysis (100%)	26 (59.1)
Partial thrombolysis (50–99%)	18 (40.9)
Number of stents >1	12 (27.3)
Stent diameter (mm)	14 [10–16]
Stent position	
Confluence coverage	28 (63.6)
Contralateral IVC wall extension	9 (20.5)
Distal to iliocaval junction	7 (15.9)
Outcomes	
Anticoagulation therapy	
Warfarin	28 (63.6)
Rivaroxaban	16 (36.4)
Stent occlusion	13 (29.5)
Contralateral DVT	5 (11.4)

Data are presented as median [min–max] and frequencies (%). CIV, common iliac vein; EIV, external iliac vein; CFV, common femoral vein; FV, femoral vein; IVC, inferior vena cava; DVT, deep venous thrombosis.

irregular wall thickening of the femoral vein on the final venogram, and the other three patients had these findings from the external iliac vein at the distal end of the stent to the femoral vein (*Figure 3*).

Immediate re-occlusion of the stent within 1 day was noted on duplex ultrasound in two patients. In both patients, the initially inserted stent covered the iliocaval confluence (Category 1), but insufficient coverage of the distal landing zone was considered to be the cause of stent occlusion. These patients were adequately retreated with CDT and additional stenting in the distal landing zone. The stents in both patients remained patent up to the final follow-up.

There were no bleeding complications related to thrombolysis during or shortly after CDT and iliac vein stenting. No symptomatic pulmonary embolism occurred during treatment.

Outcomes

The median duplex ultrasound follow-up period was 25 months (range, 1–196 months). All patients received anticoagulation therapy with 28 (63.6%) patients being treated with warfarin and 16 (36.4%) patients with

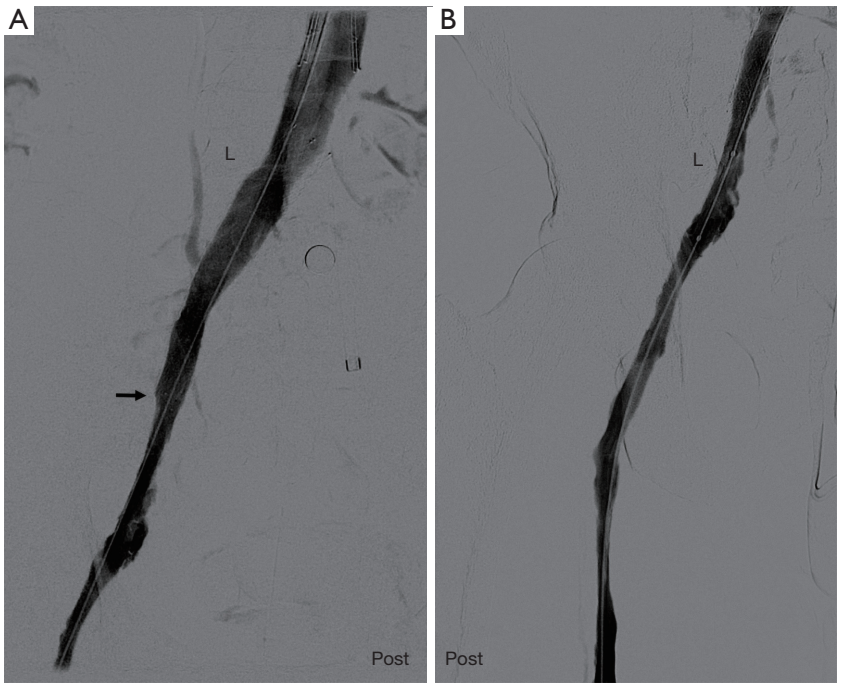

Figure 3 A 61-year-old man with subacute left-sided iliofemoral DVT secondary to MTS. Symptoms were present for 21 days before CDT. (A) Shows the iliac vein with stent, and (B) shows the more distal vein. After CDT and iliac vein stenting, the final venogram (prone position) shows diffuse and irregular wall thickening from the external iliac vein at the distal end of the stent (arrow) to the femoral vein. After 4 weeks, follow-up duplex ultrasound revealed occlusion at the distal end of the stent (image not shown). L, left side; DVT, deep vein thrombosis; MTS, May-Thurner syndrome; CDT, catheter-directed thrombolysis.

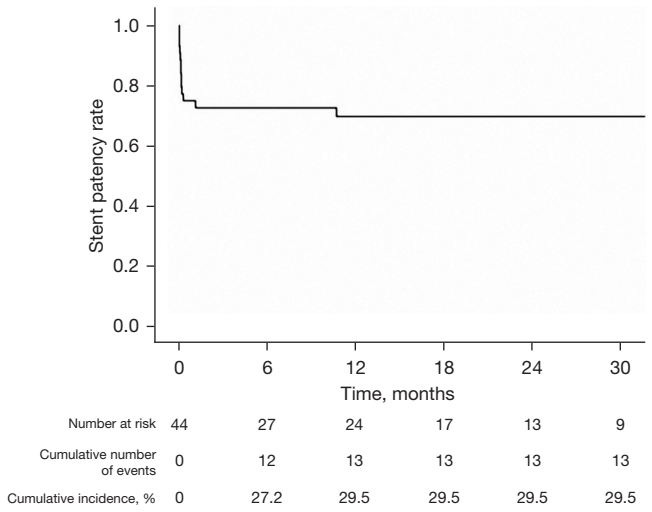

Figure 4 Cumulative stent patency in 44 patients. The overall cumulative stent patency rate at 12 months was 70.0%.

rivaroxaban. The median duration of anticoagulation was 10 months (range, 6 months to lifelong). The overall cumulative patency rates at 12 months were 70.0% (*Figure 4*). Stent occlusion occurred in 13 patients (29.5%). No specific stent type was associated with stent occlusion [Smart stents (11 of 37, 29.7%) *vs.* the other stents (2 of 7, 28.6%; one Wallstent and one Protege EverFlex)]. Among them, two patients underwent reintervention, including CDT. In one patient, stent occlusion occurred 10 months after the initial CDT and iliac vein stenting. The patient underwent CDT and additional stent implantation proximal to the previously stented segment (*Figure 5*). The other patient received additional CDT and balloon dilatation due to total stent occlusion and compression 3 days after the first procedure; however, re-occlusion occurred the next day. It was determined that an additional procedure would not be helpful for this patient, and conservative

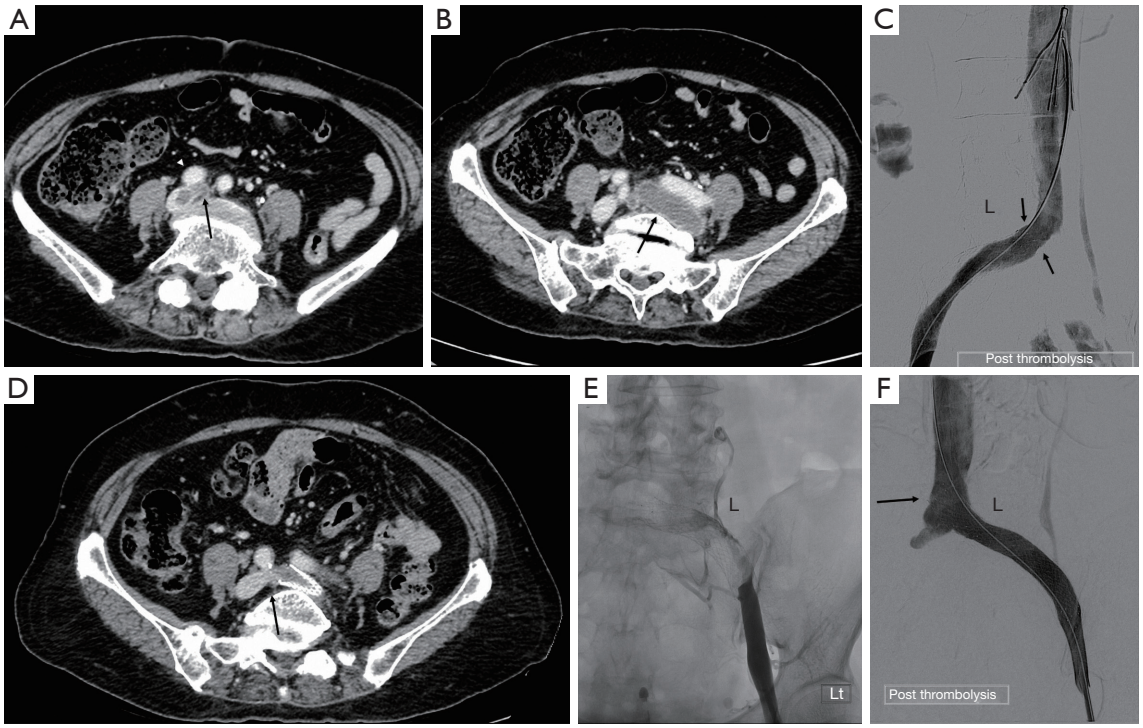

Figure 5 A 66-year-old woman with left-sided acute iliofemoral DVT secondary to MTS. (A,B) CT showing thrombosis of the distal IVC and left iliac vein (arrow), and compression of the left CIV by the right CIA (arrowhead). (C) CDT and left iliac vein stenting were performed while this was in the prone position patient. On the final venogram, successful restoration of antegrade flow could be seen. However, when retrospectively reviewing the venogram, the proximal end of the stent (arrows) was found to be located distal to the iliocaval junction. (D) Ten months after the initial CDT and iliac vein stenting, the patient was admitted for swelling of the left lower extremity. Considering the positional relationship between the right CIA and proximal end of the stent on CT, the iliocaval junction was not covered with the stent, suggesting that there was obstruction in this area (arrow). (E) In the supine position, the venogram revealed a total thrombotic occlusion of the stent. (F) The patient underwent CDT and additional stent implantation proximal to the previously stented segment (arrow). L, left side; Lt, left; DVT, deep vein thrombosis; MTS, May-Thurner syndrome; CT, computed tomography; IVC, inferior vena cava; CIV, common iliac vein; CIA, common iliac artery; CDT, catheter-directed thrombolysis.

treatment was administered. Further interventions were not performed in the remaining 11 patients with stent occlusion due to no or mildly associated symptoms (n=10) or lack of follow-up information (n=1).

Univariate and multivariate Cox regression analyses of factors associated with stent occlusion are shown in *Table 2*. Symptom duration prior to stenting [hazard ratio (HR) =10.31; P<0.001], chronic post-thrombotic lesions (HR =11.50; P<0.001), partial thrombolysis (HR =4.21; P=0.017), and stent position distal to the iliocaval junction (HR =6.58; P=0.002) were factors significantly associated with stent occlusion in the univariate analysis. Multivariate Cox regression analysis showed that chronic post-thrombotic lesions (HR =7.15; P=0.023) and stent position distal to the iliocaval junction (HR =5.59; P=0.012) were significantly associated with stent occlusion. *Figure 6* shows the multivariate-adjusted cumulative incidence curve for stent patency according to chronic post-thrombotic lesions and stent position. The characteristics of patients with stent occlusion are presented in *Table 3*.

During the follow-up period, contralateral DVT occurred in five patients. Of these, the initial stent extended to the contralateral IVC wall in three patients, and the stent was located distal to the iliocaval junction in two patients. One patient underwent CDT and right CIV stenting for contralateral DVT, and the other four patients underwent

Table 2 Univariate and multivariate Cox regression analyses of factors associated with stent occlusion after venous stenting

Variables	Univariate		Multivariate	
	HR (95% CI)	P	HR (95% CI)	P
Age	0.97 (0.92–1.02)	0.187		
Female sex	0.52 (0.17–1.6)	0.254		
Symptoms for >2 weeks prior to stenting	10.31 (3.30–32.23)*	<0.001*	4.00 (0.84–19.14)	0.083
Risk factors for venous thrombosis				
Surgery within 3 months	2.19 (0.60–7.99)	0.234		
Thrombophilia	1.72 (0.38–7.8)	0.479		
Oral contraceptive	0.73 (0.10–5.63)	0.764		
Post-procedure venography findings				
Chronic post-thrombotic lesions	11.50 (3.50–37.85)*	<0.001*	7.15 (1.32–38.81)*	0.023*
Thrombolysis grade				
Complete thrombolysis (100%)	1.0 (reference)		1.0 (reference)	
Partial thrombolysis (50–99%)	4.21 (1.29–13.78)*	0.017*	0.91 (0.17–4.82)	0.909
Stent characteristics				
Number of stents >1	1.85 (0.60–5.65)	0.282		
Stent diameter (mm)	0.98 (0.67–1.43)	0.897		
Stent position				
Confluence coverage	1.0 (reference)		1.0 (reference)	
Contralateral IVC wall extension	1.19 (0.23–6.14)	0.836	1.07 (0.20–5.73)	0.933
Distal to iliocaval junction	6.58 (1.97–21.9)*	0.002*	5.59 (1.46–21.38)*	0.012*

*, statistically significant associations. HR, hazard ratio; CI, confidence interval; IVC, inferior vena cava.

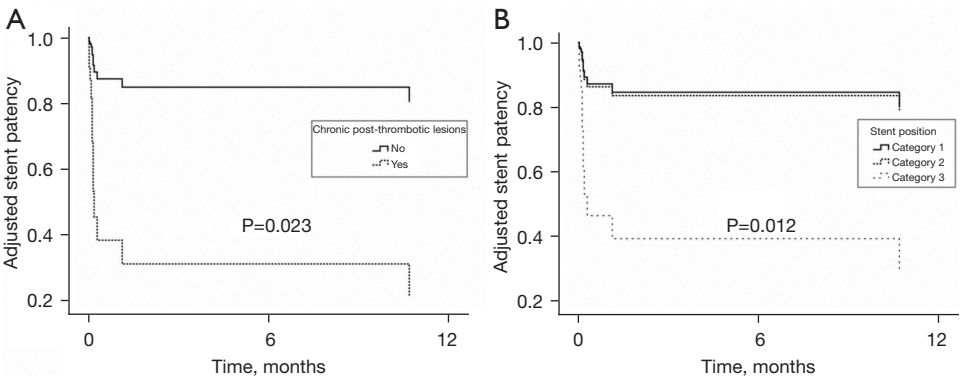

Figure 6 Multivariate Cox regression analysis of stent patency. (A) Adjusted survival curves showing stent patency according to the presence of chronic post-thrombotic lesions on final venography. (B) Adjusted survival curves showing stent patency according to the category of stent position: Category 1 (covering the iliocaval confluence without touching the contralateral IVC wall); Category 2 (extending to the IVC, contacting the contralateral IVC wall); and Category 3 (distal to the iliocaval junction and not covering the confluence). IVC, inferior vena cava.

Table 3 Patient characteristics of stent occlusion

Patient	Age/sex	Symptom duration, days	Risk factor	Stent position	Chronic post-thrombotic lesions	Time at stent occlusion, days	Subsequent management
1	23/male	20	Idiopathic	Category 3	Yes	16	Warfarin (12 months)
2	36/female	20	Thrombophilia (lupus anticoagulants)	Category 3	Yes	14	Warfarin (lifelong)
3	27/female	15	Oral contraceptive	Category 3	No	14	Warfarin (lifelong)
4	51/male	5	Idiopathic	Category 1	No	11	Warfarin (lifelong)
5	48/male	15	Idiopathic	Category 2	Yes	15	Warfarin (lifelong)
6	46/male	7	Idiopathic	Category 3	No	22	Warfarin (lifelong)
7	64/female	10	Recent surgery	Category 2	No	15	Warfarin (7 months) follow-up loss thereafter
8	29/female	11	Recent surgery	Category 3	No	19	Warfarin (12 months)
9	61/male	21	Idiopathic	Category 1	Yes	34	Warfarin (27 months)
10	66/female	4	Cardiopulmonary disease	Category 3	No	321	Additional stenting
11	44/male	30	Recent surgery	Category 1	Yes	13	Rivaroxaban (6 months)
12	59/male	15	Immobilization	Category 1	No	17	Warfarin (6 months)
13	51/male	20	Thrombophilia (anti-cardiolipin antibodies)	Category 1	Yes	3	Stent expansion with balloon → reocclusion → rivaroxaban (6 months)

Category 1, covering the iliocaval confluence without touching the contralateral IVC wall; Category 2, extending to the IVC, contacting the contralateral IVC wall; Category 3, distal to the iliocaval junction and not covering the confluence. IVC, inferior vena cava.

conventional anticoagulation therapy.

Discussion

In our study, 29.5% of patients with iliofemoral DVT secondary to MTS who underwent CDT and iliac vein stenting developed stent occlusion after a median follow-up of 25 months. The overall cumulative patency rate at 1 year was 70.0%. Multivariate Cox regression identified chronic post-thrombotic lesions, and stent position distal to the iliocaval junction were risk factors for stent occlusion.

In our study, stent occlusion occurred in six out of seven cases of the stent located distal to the iliocaval confluence. Although the flow in the stent may be intact on venography immediately after iliac vein stenting, the following problems may occur if the stent does not sufficiently cover the iliocaval confluence. The upper end of the stent, with a relatively weak radial force, is continuously compressed by the fibrotic lesion and pulsating arterial over-riding in the cranial portion of the CIV. This causes the stent to gradually transform into a cone shape, resulting in distal migration of the stent (watermelon seeding), which can cause stent occlusion as a result of outflow obstruction (25,26). Conversely, if the stent extends beyond the iliocaval confluence to reach the contralateral IVC wall, it can impair the contralateral venous outflow, commonly known as "jailing", which in turn increases the risk of contralateral DVT (27). If contralateral DVT occurs, its management can be difficult; there may be difficulties in cannulating through the side of the crossing stent (26,28). In our study, contralateral DVT occurred in three out of nine cases where the stent location extended to the contralateral IVC wall. In one case, additional stenting was performed in the right CIV; however, the procedure presented significant technical difficulties. Therefore, it is ideal to insert a stent to cover the iliocaval confluence without touching the contralateral IVC wall; however, determining the location of the confluence using venography can be inaccurate. Because stenotic iliac vein lesions can be elliptical or flattened, venography, even with multiplanar techniques,

has limited views that may miss highly eccentric lesions. Intravascular ultrasound (IVUS) is considered the most accurate method for evaluating the iliocaval confluence (29). According to a systematic review, it was reported that venography underestimated the severity and presence of venous stenosis, and IVUS identified stenotic lesions in up to 30% more patients compared to multiplanar venography (30). However, IVUS is still not widely used due to its high cost, and unfortunately, we do not have IVUS in our department. Therefore, several studies have recently introduced a method of stent placement without IVUS. Bajwa'R *et al.* reported accurate venous stent placement using fluoroscopy only based on the relationship between bony landmarks and predictable locations in patients with MTS (31). Other methods of using a pressure gradient or pulling the inflated balloon to feel resistance have also been reported for iliac vein stenting (32,33). However, the use of bony landmarks may be limited in alternative spine anatomy such as scoliosis or pedicle variants. Pressure gradient measurements can be affected by the patient's position and respiration (31,32).

In our study, seven patients had chronic post-thrombotic lesions in the femoral vein on the final venogram, and stent occlusion occurred in six cases. In four cases, the stent sufficiently covered the iliocaval confluence, but stent occlusion occurred. According to a study that reported long-term outcomes of 191 patients with iliofemoral DVT treated using CDT, the absence of chronic post-thrombotic lesions resulted in better primary patency, including normal valve function (24). Avgerinos *et al.* reported that incomplete lysis (<50%) after CDT in patients with DVT was an independent predictor of primary patency (21). In their study, the residual thrombus was considered a chronic thrombotic lesion, necessitating stent placement. A possible explanation for stent occlusion due to chronic post-thrombotic lesions is insufficient inflow (26). Since we only evaluated vessel stenosis and vessel wall irregularity using venography alone, the appropriate distal landing zone could not be properly identified, and distal stenosis may have been overlooked. Although the stenosis location can be evaluated using multiple angled projections or combining collaterals, pancaking, and contrast thinning with venography, this method has limitations relative to IVUS, and is particularly limited in evaluating external iliac and common femoral vein lesions (34,35).

In present study, symptom duration >2 weeks before CDT and partial thrombolysis (50–99% of thrombus removal) were significantly associated with stent occlusion in univariate Cox regression, but not in multivariate Cox regression. Of the 18 patients with partial thrombolysis, 9 did not develop stent occlusion. Eight of these nine patients had only focal residual thrombus in the common femoral vein or femoral vein on the final venogram. This suggests that diffuse chronic post-thrombotic change is more associated with stent occlusion than symptom duration or partial thrombolysis.

We had a 70% stent patency at 1 year, and most stent occlusions occurred within 1 month after the intervention. Other studies have reported that stent occlusion after iliac vein stenting in patients with acute DVT occurs mostly within 1–3 months and that short-term follow-up is important (21,36). In a large series with iliocaval stenting in 982 patients, primary patency at 72 months was 79% and 57% in non-thrombotic and thrombotic disease, respectively (12). According to a systematic review of deep venous stenting for acute DVT, the primary, assisted primary, and secondary patency rates 12 months after stent placement ranged from 74% to 95%, 90% to 95%, and 84% to 100%, respectively (37). The primary patency rate of 70% in our study was somewhat unsatisfactory when compared to that reported in the abovementioned systematic review. We only used venography, and in several cases, the proximal and distal landing zones may have been inappropriately evaluated. This resulted in improper stent positioning and stent occlusion.

We experienced 13 cases of stent occlusion, but 10 did not undergo reintervention because of no (n=7) or mild symptoms (n=3; mild edema or leg discomfort). In addition, the 10 patients showed no symptoms of aggravation during a median follow-up of 40.5 months (range, 21–160 months). Che *et al.* reported a patient with a pressure gradient of only 2 mmHg between the left external iliac vein and IVC due to pelvic collaterals, although obvious stenosis of the left CIV was observed on venography. They only performed conservative anticoagulation therapy on this patient, and the patient did not develop post-thrombotic syndrome on follow-up (32). Matsuda *et al.* showed that there is no need for an iliac vein stent in patients with abundant collateral circulation of the pelvic vein (38). In our study, the absence or mild symptoms in patients with stent occlusion may be due to the collateral flow mentioned above. However, since no additional venography or CT was performed on these patients after stent occlusion, it is difficult to accurately explain them. Additional case studies are required to clarify this.

Unlike other CDT studies, in our study, most patients

(93.2%) underwent combined aspiration thrombectomy with CDT. Aspiration thrombectomy has the advantage of reducing the procedure time and hemorrhagic complications because it can rapidly remove the thrombus with a lower dose of thrombolytic agent. Several studies have reported the efficacy and safety of aspiration thrombectomy (39,40).

Our study has a few limitations. First, as a retrospective study, the inherent bias in patient selection was inevitable. Second, this study has a small sample size and was conducted at a single center. Third, we did not include the Villalta scale or Venous Clinical Severity Score as outcome endpoints to assess patients' clinical symptoms, especially post-thrombotic syndrome, due to incomplete data in the medical records (41). Fourth, wide variability in the stent type is another potential limitation.

In conclusion, chronic post-thrombotic lesions and stents distal to the iliocaval junction were important risk factors for stent occlusion in patients who underwent CDT and iliac vein stenting. Technological development regarding stenting will contribute to improving clinical outcomes, including patency.

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Footnote

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-22-515/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The present study was approved by the Institutional Review Board of Samsung Medical Center. The requirement for written informed consent was waived due to the retrospective nature of the study.

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