

Single- versus multiple-stage catheter-directed thrombolysis for acute iliofemoral deep venous thrombosis does not have an impact on iliac vein stent length or patency rates



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ABSTRACT

Background: Incomplete venous thrombolysis and residual nonstented iliac vein disease are known predictors of recurrent deep venous thrombosis (DVT). Controversy exists as to whether the number of thrombolysis sessions affects total stent treatment length or stent patency. The goal of this study was to evaluate the outcomes of patients who underwent single vs multiple catheter-directed lysis sessions with regard to stent extent and patency.

Methods: Consecutive patients who underwent thrombolysis and stenting for acute iliofemoral DVT between 2007 and 2018 were identified and divided into two groups on the basis of the number of treatments performed (one vs multiple sessions). Operative notes and venograms were reviewed to determine the number of lytic sessions performed and stent information, including size, location, total number, and length treated. End points included total stent length, 30-day and long-term patency, and post-thrombotic syndrome (Villalta score ≥ 5). The χ^2 comparisons, logistic regression, and survival analysis were used to determine outcomes.

Results: There were 79 patients who underwent lysis and stenting (6 bilateral interventions; mean age, 45.9 ± 17 years; 48 female). Ten patients (12 limbs) underwent single-stage treatment with pharmacomechanical thrombolysis, and the remaining 69 (73 limbs) had two to four operating room sessions combining pharmacomechanical and catheter-directed thrombolysis. Patients who underwent a single-stage procedure were older and more likely to have a malignant disease. These patients received less tissue plasminogen activator compared with the multiple-stage group (17.2 ± 2.2 mg vs 27.6 ± 11.6 mg; $P = .008$). Average stent length was 8.8 ± 5.2 cm for the single-stage group vs 9.2 ± 4.6 cm for the multiple-stage group ($P = .764$). Patients who underwent a single-stage procedure had no difference in average length of stay from that of patients who underwent multiple sessions (8.5 days vs 5.9 days; $P = .269$). The overall 30-day rethrombosis rate was 7.3%. Two-year patency was 72.2% and 74.7% for the single and multiple stages, respectively ($P = .909$). The major predictors for loss of primary patency were previous DVT (hazard ratio [HR], 5.99; $P = .020$) and incomplete lysis (HR, 5.39; $P = .014$) but not number of procedures (HR, 0.957; $P = .966$). The overall post-thrombotic syndrome rate was 28.4% at 5 years and was also not associated with the number of treatment sessions.

Conclusions: Single- vs multiple-stage thrombolysis for DVT is not associated with a difference in extent of stent coverage. Patency rates remain high for iliac stenting irrespective of the number of lytic sessions, provided lysis is complete and the diseased segments are appropriately stented. (J Vasc Surg: Venous and Lym Dis 2019;7:781-8.)

Keywords: Stent length; DVT lysis; Acute DVT; Staged CDT; Single-session PMT

During the past decade, catheter-based interventions have been increasingly used in the treatment of acute proximal deep venous thrombosis (DVT). Catheter-directed thrombolysis (CDT) has been supported as a safe and effective intervention that can rapidly reduce thrombus burden, allow faster symptom relief, and maintain valve function.¹⁻⁴ Results of various retrospective and prospective randomized studies comparing CDT with conservative therapy for lower extremity DVT have been

inconsistent.¹⁻⁶ Recent studies have shown that CDT improves the patency of iliofemoral vein and post-thrombotic severity with an equivocal risk of bleeding.^{2,7-9} Current guidelines recommend early thrombus removal using percutaneous catheter-based techniques mainly in patients with symptomatic proximal DVT with good life expectancy and low bleeding risk.¹⁰

Whereas our knowledge of technical aspects and predictors of failure continues to evolve, stenting after

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CDT is supported as a critical component of a successful intervention in those patients with underlying iliac vein stenosis or residual thrombus.^{9,10} Catheter-based thrombolysis can be performed in one or more stages. A single-stage procedure will typically involve pharmacomechanical thrombolysis (PMT), whereas multiple stages may be needed when thrombus is extensive or resistant to the single-stage PMT. Some physicians will opt to terminate the procedure at a single stage and cover the residual thrombus with a stent; others will opt to drip thrombolytics for a few hours to minimize clot burden and potentially reduce the stent length needed to cover the residual lesion or thrombus burden.¹¹⁻¹³

Although incomplete venous thrombolysis and residual nonstented iliac vein disease are known predictors of failure of iliac vein stenting,^{14,15} controversy exists as to whether the number of thrombolysis sessions affects stent patency or total stent treatment length.^{12,13} Novel large-bore thrombectomy devices are entering the market to satisfy an increasing demand for higher clot clearance rates and single-session therapies. It is thus imperative to better define the sequelae of single-stage PMT. This study aimed to evaluate the outcomes of iliac vein stenting in patients who underwent single vs multiple lysis sessions before stent placement.

METHODS

This study was approved by the University of Pittsburgh Institutional Review Board.

Study design. Consecutive patients who underwent endovascular intervention including CDT and PMT with stenting for acute, symptomatic iliofemoral DVT between 2007 and 2018 were identified and divided into two groups on the basis of the number of treatment sessions. Patients' demographics, thrombotic risk factors, imaging, symptoms, procedural data, and postoperative outcomes were recorded. Operative notes and venograms were reviewed to determine the number of lytic sessions that were performed and stent characteristics, including size, location, and length treated. Primary end points were total stent length and ipsilateral DVT recurrence; post-thrombotic syndrome (PTS), defined by a Villalta score ≥ 5 , was the secondary end point.

Definitions. Stent length was evaluated and measured by reviewing operative notes and venograms. To account for tortuosity and stent overlap, radiopaque markers of the angioplasty balloons used intraoperatively served as a reference to measure total stent length. Extension below the inguinal ligament was defined as the visualization of the distal tip of the stent below the cranial border of the femoral head.

The rate of clot lysis was determined as previously described.^{16,17} Briefly, both before and after treatment (lysis, venoplasty, and stenting), thrombus was graded by degree of luminal reduction throughout the

ARTICLE HIGHLIGHTS

- **Type of Research:** Single-center retrospective comparative review
- **Key Findings:** In comparing single-stage pharmacomechanical thrombolysis (n = 12 limbs) vs multisection thrombolysis (n = 73 limbs) followed by iliac vein stenting, there was no difference in overall stent length (8.8 vs 9.2 cm; $P = .764$) or 2-year primary patency (72.2% vs 74.7%). Incomplete lysis was a strong predictor of stent thrombosis.
- **Take Home Message:** Single- vs multiple-stage thrombolysis for deep venous thrombosis is not associated with differences in extent of stent coverage or patency. Patency remains high as long as lysis is complete and all residual disease is stented.

iliofemoral system. The difference in scores then translated into a binary variable: $>50\%$ clearance of thrombus or $<50\%$. Patency was defined as any in-line flow. The physicians reviewing the venograms (C.G., E.A.) were blinded to clinical outcomes. Freedom from rethrombosis was defined as maintained patency of the treated iliofemoral or caval segment, irrespective of the popliteal or distal vein segments. Length of stay was measured in days and defined as postoperative day 1 to day of discharge.

Major bleeding events included bleeding significant enough to require intervention, transfusion of at least 2 units of red blood cells, and involvement of the central nervous system (eg, intracerebral or epidural).^{2,6} All other bleeding episodes were considered minor. Acute kidney injury was defined as an increase in serum creatinine concentration by twofold or greater with resolution to baseline within 30 days.

Perioperative management and follow-up. All patients underwent duplex ultrasound examination to confirm DVT diagnosis and to evaluate extent of thrombosis. Intravenous unfractionated heparin infusion was initiated according to hospital-wide DVT protocol to maintain therapeutic levels (activated partial thromboplastin time of 68-106 seconds or anti-factor Xa levels of 0.3-0.7 units/mL). All procedures were performed by board-certified vascular surgeons in a hybrid operating room equipped with fixed fluoroscopy imaging. After the procedure, patients were bridged to full oral anticoagulation with duration according to national guidelines. All patients, unless it was contraindicated, were maintained on dual antiplatelet therapy with aspirin and clopidogrel for at least 1 month. Stent patency was evaluated by duplex ultrasound at 1 month, 3 months, 6 months, and 12 months and annually thereafter. Symptom severity evaluations were performed at clinical follow-up, which did not always coincide with duplex

ultrasound follow-up. Villalta scores were estimated by blinded authors through retrospective review of clinic documentation.

Thrombolysis technique. Our technique used at the University of Pittsburgh Medical Center has been described thoroughly elsewhere.¹⁸ All procedures were performed under conscious sedation. In brief, venography was performed through 6F or 8F sheaths. Early in our practice, overnight tissue plasminogen activator (tPA; Alteplase, Genentech, San Francisco, Calif) administration followed by PMT in a second or third session was preferred; as experience and evidence evolved over the years, PMT became a first-line treatment, followed selectively by CDT when the treating physician thought that thrombus clearance was inadequate. In our practice, PMT is most often performed with the AngioJet catheter (Boston Scientific, Marlborough, Mass), typically using 6 to 10 mg of tPA. Our study does include some use of the Trellis device (Covidien Vascular, Mansfield, Mass), which was later removed from the market. Using the Trellis, we delivered a similar quantity of tPA in 30-cm segments. CDT was performed using a standard multiside hole catheter and tPA infusion from 0.25 to 1.00 mg/h without weight adjustment in addition to a fixed intravenous heparin infusion of 500 units/h. Fibrinogen and hemoglobin levels were measured every 6 hours. Lysis check with venography was repeated at 8 to 24 hours. At each session, it may have been elected to continue CDT, to attempt PMT, or to terminate lysis. This was at the discretion of the operator. Residual iliac vein stenosis, anatomic or thrombotic, was treated with balloon venoplasty and self-expanding stents of varying diameters to treat the diseased vein segments. At our institution, intravenous ultrasound became more widely adopted in 2017. Because of small numbers, it was excluded from our analysis. When intravenous ultrasound was not used, multiple venography projections were obtained before stenting. The common iliac vein and the external iliac vein were typically stented with 14- to 20-mm and 12- to 16-mm stents, respectively.

Statistical analysis. Patients were divided into two groups on the basis of the number of treatment procedures performed—single session vs multiple sessions. Descriptive baseline characteristics and postoperative outcomes were compared between the groups and were displayed as number of cases and percentages for categorical variables and mean \pm standard deviation for continuous variables. Whereas preoperative baseline risk factors and perioperative complications were analyzed at the patient level, procedural characteristics and clinical outcomes including DVT recurrence, stent failure, and PTS were studied at the limb level. The χ^2 test was used to compare categorical variables; the

Student *t*-test (continuous) and Wilcoxon rank sum test (discrete) were used for quantitative variables.

Logistic regression analysis was used to identify predictors of 30-day rethrombosis or stent failure. Results were presented as odds ratios (ORs) and *P* values. Long-term primary patency and PTS were assessed using Kaplan-Meier survival analysis. The effect of baseline and operative predictors, including number of procedures and total stented length, on study end points was evaluated using multivariable Cox regression models. Results were expressed as hazard ratios (HRs). Associations were considered statistically significant when *P* < .05.

Statistical analyses were performed using Stata/SE 15.0 for Windows (StataCorp LLC, College Station, Tex).

RESULTS

Eighty-five limbs in 79 patients (mean age, 45.9 \pm 17 years; 48 female) were lysed and stented. Ten patients (12 limbs) underwent single-stage treatment with PMT, and the remaining 69 patients (73 limbs) had staged treatments in two to four sessions combining PMT and CDT (Table I). Of the 73 limbs in the multiple-session group, 28 underwent PMT first followed by lytic infusion for residual thrombus, 34 had infusion therapy first followed by PMT, and 11 had lytic infusion alone. Four patients in the single-stage group received treatment with the Trellis device only, whereas an additional four had combined Trellis and AngioJet. In the multiple-stage group, 11 underwent PMT with the Trellis device and another 5 had both Trellis and AngioJet treatments. Patients who underwent single-stage thrombolysis were significantly older and more likely to have a malignant disease or thrombosed indwelling IVC filters. The presenting symptom in >80% of patients was the combination of pain and swelling of the extremity, whereas 1 limb (8.3%) in the single-stage group and 11 in the multiple-session group (15.1%; *P* = .555) showed evidence of phlegmasia.

Periprocedural outcomes. Single-session PMT required significantly less tPA per patient (17.2 \pm 2.2 mg vs 27.6 \pm 11.6 mg; *P* = .008). The rate of successful lysis (>50% clearance of thrombus) was similar between the two groups (single session, 83.3%; multiple sessions, 79.2%; *P* = .739). There were no significant differences in the anatomic distribution of stents between groups (Table I). The average diameters of the common iliac vein stents were 13.5 \pm 1.4 mm and 15.5 \pm 1.7 mm for the single-session and multiple-session groups, respectively (*P* = .003), and 11.7 \pm .82 mm and 14.2 \pm 2.1 mm for the external iliac vein (*P* = .005). The average number of stents and total treatment length for single sessions were 1.5 \pm 0.80 stents and 8.8 \pm 5.2 cm, respectively. This did not differ from the multisession therapy, which averaged 1.7 \pm 0.84 stents (*P* = .340) and covered 9.2 \pm 4.6 cm (*P* = .764). In univariate analysis, treated segments

Table I. Baseline characteristics, technical results, and postoperative follow-up by group

	Single procedure	Multiple procedures	P value
Patients (limbs)	10 (12)	69 (73)	
Age, years	60.1 ± 18.2	43.9 ± 15.9	.004
Female	5 (50)	43 (62.3)	.456
BMI, kg/m ²	38.8 ± 11.6	32.1 ± 9.8	.076
Clinical presentation			
Symptom duration, days	13.9 ± 9.1	9.7 ± 9.9	.203
>14 days of symptoms	40.0	20.3	.165
Phlegmasia	8.3	15.1	.555
PE on presentation	0.0	11.6	.261
Thrombosed IVC filter	66.7	19.1	.001
Risk factors			
Current smoker	0.0	22.1	.098
Previous DVT	60.0	40.6	.252
Hypercoagulability	30.0	33.3	.840
Malignant disease	40.0	10.1	.010
Limited ambulation	80.0	52.2	.098
Recent surgery/trauma	40.0	23.2	.253
Procedural results			
Total tPA, mg	17.2 ± 2.2	27.6 ± 11.6	.008
Incomplete (<50%) lysis	16.7	20.8	.739
No. of stents	1.5 ± 0.80	1.7 ± 0.84	.340
Treated length	8.8 ± 5.2	9.2 ± 4.6	.764
Stent location			
Extending into IVC	16.70	37.00	.169
Common iliac vein	100.0	88.9	.225
External iliac vein	50.0	68.1	.223
Below inguinal ligament	16.7	24.7	.545
Stent diameter, mm			
Common iliac vein	13.5 ± 1.4	15.5 ± 1.7	.003
External iliac vein	11.7 ± .82	14.2 ± 2.1	.005
Postoperative outcomes			
30-day rethrombosis	8.3	7.1	.884
Length of stay, days	8.5 ± 6.8	5.9 ± 6.8	.269
Long-term follow-up			
Follow-up, months	44.7 ± 33.2	24.4 ± 30.2	.037
Symptom resolution	100	92.9	.345
2-year patency	72.2	74.7	.909
PTS at 3 years	9.1	15.0	.379

BMI, Body mass index; DVT, deep venous thrombosis; IVC, inferior vena cava; PE, pulmonary embolism; PTS, post-thrombotic syndrome; tPA, tissue plasminogen activator.

Categorical variables are presented as number (%) or percentages. Continuous variables are presented as mean ± standard deviation. Boldface entries indicate statistically significant differences between groups ($P < .05$).

were longer when extending into the common femoral vein (CFV; 14 ± 5.1 cm vs 7.6 ± 3.4 cm; $P < .001$) and for limbs with incomplete thrombolysis (11.5 ± 5.3 cm vs 8.6 ± 5.1 cm; $P = .037$).

Complications. There were three major bleeding events in the single-session group and two in the staged group. In the single-session group, one patient

had a large rectus sheath hematoma that led to obstructive uropathy and acute kidney injury requiring percutaneous nephrostomy tubes; two other patients required blood transfusions (2 units each). Within the multiple-session cohort, there was one popliteal access site hematoma that needed to be evacuated surgically. This same patient also developed an internal jugular access site hematoma that became infected and

required incision and drainage. Another patient required a 4-unit blood transfusion. Other minor bleeding events included a jugular sheath hematoma and a rectus sheath hematoma, both in the staged group. The incidence of acute kidney injury was 10% (n = 1) and 4.4% (n = 3) in the single-session and multiple-session groups, respectively (P = .454). The average length of stay did not differ between groups (single session, 8.5 ± 6.8 days; multiple sessions, 5.9 ± 6.8 days; P = .269). In comparing the PMT-first vs CDT-first treatment, there was no difference in length of stay (6.1 ± 4.5 vs 6.4 ± 8.5 days, respectively; P = .880).

Postoperative outcomes. The overall 30-day rethrombosis rate was 7.3% and did not differ between groups. The major predictor for 30-day failure was incomplete lysis or >50% residual thrombus burden (OR, 5.01; P = .015). The total number of procedures, total stented length, and stent extension into the cava or below the inguinal ligament did not predict 30-day failure (Table II). Mean duplex ultrasound follow-up for the single- and

multiple-stage groups were 44.7 ± 33.2 months and 24.4 ± 30.2 months, respectively (P = .037). Overall primary patency at 1 year, 3 years, and 5 years was 79.9%, 73.5%, and 73.5%. At 2 years, patency was comparable between single- and multiple-stage groups (72.2% vs 74.7%; P = .909). The Fig summarizes stent patency to 24 months for both groups. The strongest predictors of stent failure were previous DVT history (HR, 5.99; P = .020) and incomplete lysis (HR, 5.39; P = .014). Increased age was associated with better primary patency (HR, 0.920; P = .002). Neither the number of lysis sessions nor the total stented length was predictive of failure. Multivariate analysis of primary patency predictors is presented in Table II.

Mean clinical follow-up for the single- and multiple-stage groups was 54.4 ± 32.6 months and 29.4 ± 32.1 months, respectively (P = .015). Moderate to complete resolution of symptoms was observed in 100% of the single-stage group and 92.9% of the multiple-stage group (P = .345). At 1 year, 3 years, and 5 years, overall freedom from PTS (Villalta score <5) was 89.6%, 85.9%, and 71.6%; there was no difference between the two groups. Significant univariate predictors of PTS included stents extending below the inguinal ligament (HR, 4.11; P = .005), thrombosed indwelling filter at presentation (HR, 3.08; P = .026), previous DVT (HR, 2.62; P = .048), duration of symptoms in days (HR, 1.05/day; P = .024), and female sex, which was protective (HR, 0.317; P = .022). On multivariate analysis, only infrainguinal stenting predicted PTS development (HR, 3.00; P = .036). Number of lysis sessions, total stented length, and lysis completion did not significantly affect the risk for development of PTS (Table II).

Table II. Summary of logistic regression for 30-day failure and Cox proportional hazards models for primary patency and post-thrombotic syndrome (PTS)

30-day failure	OR	P value
Incomplete (<50%) lysis	5.01	.015
Phlegmasia on admission	3.48	.098
Symptoms >14 days	3.48	.104
Single session/PMT only	1.14	.883
Treated length	1.16	.055
Total tPA	1.04	.232
Stent extension into IVC	0.682	.559
Stent below inguinal ligament	0.353	.243
Primary patency	HR	P value
Malignant disease	7.70	.122
Previous DVT	5.99	.020
Incomplete (<50%) lysis	5.39	.014
Stent below inguinal ligament	2.89	.209
BMI	1.05	.252
Single-session/PMT only	0.957	.966
Age of patient	0.920	.002
Treated length	0.904	.254
PTS	HR	P value
Stent below inguinal ligament	3.00	.036
Incomplete (<50%) lysis	1.62	.491
Age of patient	1.01	.418
Single session/PMT only	0.847	.805
Female sex	0.371	.061

BMI, Body mass index; DVT, deep venous thrombosis; HR, hazard ratio; IVC, inferior vena cava; OR, odds ratio; PE, pulmonary embolism; PMT, pharmacomechanical thrombolysis; tPA, tissue plasminogen activator. Boldface entries indicate statistically significant differences between groups (P < .05).

DISCUSSION

PMT or CDT followed by stenting has become an established treatment alternative for acute, symptomatic ilio-femoral DVTs in select patients. PMT and lytic infusion have repeatedly been shown to have comparable

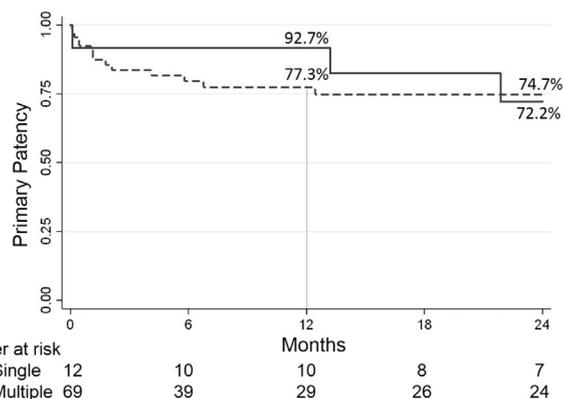


Fig. Kaplan-Meier survival functions for primary patency for both single-stage and multiple-stage lysis and stenting.

technical success rates, safety profiles, and symptom relief.¹⁰⁻¹³ Catheter-directed therapy is limited, however, as it requires a multistage process including prolonged tPA infusion times and monitoring in the intensive care unit. PMT allows immediate thrombus extraction and simultaneous lytic infusion; it has been associated with fewer venograms, decreased thrombolytic doses, shorter intensive care unit and hospital stays, and lower overall costs.^{11,19} Thus, the current recommendation is to complete DVT lysis and stent placement within a single procedure if resources are available.¹⁰ We hypothesized that forcing single-stage procedures might result in longer vein segments with residual thrombus that would require longer stent use. Our data did not confirm this hypothesis and are consistent with current evidence—significantly less lytic agent infused with no difference in clinical and anatomic success—supporting the efficacy of single-stage procedures.

To date, only two groups have directly studied single-vs multiple-session venous thrombolysis and stenting. Dopheide et al¹² from Switzerland investigated stent length after PMT only using AngioJet Zelante (Boston Scientific) vs PMT as a bailout after failed CDT. The PMT-only group ($n = 11$) received on average longer stents than the bailout group ($n = 13$), but this difference was not significant (23.6 cm vs 18.5 cm; $P = .180$), which mirrors our results. Liu et al¹³ from Shanghai compared outcomes of stenting after a single session of AngioJet thrombolysis with those following combined rheolytic thrombolysis and CDT with subsequent stenting in 91 patients. Their findings suggested that single-stage procedures resulted in less complete thrombus clearance (81.5% vs 85.7%; $P < .001$). Their group also reported significantly longer stent lengths (10.1 cm vs 8.67 cm; $P = .020$) in the direct group, which they hypothesized was due to decreased thrombus clearance. This hypothesis is supported by our data, in which $<50\%$ thrombus clearance is associated with longer treatment segments. In our data set, the number of treatment sessions was not associated with low thrombus clearance, which is why we found no difference in the length of stents needed.

Critics of the Acute Venous Thrombosis: Thrombus Removal with Adjunctive Catheter-Directed Thrombolysis (ATTRACT) and Catheter-directed Venous Thrombolysis in Acute Iliofemoral Vein Thrombosis (CaVenT) trials have noted the sparse use of stents, which may partly explain the marginal benefit of endovascular intervention over anticoagulation alone.²⁰ Liberal stenting of residual lesions is critical for optimal outcomes. Primary patency of stents after PMT ranges between 79% and 100% at 1 year to between 60% and 90% at 5 years.^{11-14,21-25} Our observed patency rates fall squarely within this range and meet the performance goals described by Razavi et al²¹ in their 2015 meta-analysis of iliac vein stenting. Because of its impact on quality of

life and the potential for development of PTS, stent thrombosis is an important complication to prevent. We have previously emphasized the importance of thorough thrombus clearance to prevent early and late stent thrombosis.¹⁴ We also found age to be protective from reocclusion, which is consistent with the work by Neglen and Raju,²⁶ which suggested that younger patients were more likely to exhibit in-stent restenosis. Stented length and stenting below the inguinal ligament have also been evaluated as predictors of patency with controversial results. In 2008, Park et al²⁷ in Seoul, Korea, found that limbs with >6 cm of stented vessel were 13 times more likely to rethrombose after CDT and stenting than those with shorter treated segments (HR, 13; $P = .008$). Although Park et al acknowledged that there is no pathophysiologic evidence available from a venous standpoint, their group attributes their findings to arterial and coronary evidence that longer stents are prone to more restenosis. In our investigation, treated length as a continuous variable did not affect patency rates. However, in a univariate post hoc subanalysis in which we used 6 cm as a cutoff, we found that limbs treated with >6 cm of stents were more likely to fail in the first 30 days (OR, 1.52; $P = .008$) but not in the long term. Early failure is either technical or due to the severity of disease rather than directly a consequence of stent length. In addition, the average stent diameter in Park's study was 13 mm, whereas ours was 15.3 mm, which could explain patency differences. With regard to the inguinal ligament, whereas Neglen et al²² demonstrated association with worse secondary patency with infrainguinal extension, the difference was lost when limbs were stratified by cause of disease. In a study by Stuck et al²³ from Switzerland, patients with stent failure had more stents placed (2 vs 1.6; $P = .020$), but stent length was not described or analyzed. They further reported that limbs requiring CFV stenting tended to predict loss of primary patency (OR, 2.59; $P = .050$), which did not quite reach statistical significance. Similarly, we found that stenting below the inguinal ligament was not predictive of patency.¹⁴

The paramount clinical significance of venous recanalization is not only symptomatic relief but long-term prevention of lower extremity venous congestion and its sequelae. The ATTRACT trial subanalysis may have not shown a difference in the occurrence of PTS compared with anticoagulation alone, but it did report a benefit in regard to severity of symptoms and quality of life.⁸ Both Dopheide et al¹² and Liu et al¹³ demonstrated increased Villalta scores at 6 months (2.3 vs 1.1; P not reported) and 12 months (4.2 vs 2.1; $P = .001$), respectively, with single-vs multiple-stage treatment—although these did not reach PTS criteria. Our group has previously shown that there is no difference in valve function at 2 years between single-stage PMT and combined CDT and PMT (73.9% vs 59%; $P = .482$) and also reported a

median Villalta score of 4 vs 2 ($P = .392$) for the single-session vs multiple-session groups, respectively.¹¹ Neither number of lysis sessions nor stent length was a predictor for PTS. However, stenting below the inguinal ligament remained a significant predictor even in the multivariate model. Stenting within the CFV may be a sign of more extensive disease rather than a cause-and-effect relationship.¹⁴

The limitations of our study include the inherent bias of retrospective data collection. Patients received single or multiple lysis sessions on the basis of the physician's preference. In general, patients who were deemed higher medical risk or poor candidates for lytic therapy were offered single-stage PMT only. This may explain the lack of difference in hospital stay against the multiple-session groups. Furthermore, we are not able to accurately report "technical success" of single-session PMT. Twenty-eight cases that were initially planned for a single session underwent multiple sessions because the treating physician was not satisfied with thrombus clearance, thus restricting our ability to demonstrate a difference in stent length. However, even when excluding the PMT-first patients and comparing CDT-first against single-stage PMT, there was no difference in stented length (10 ± 5.0 cm vs 8.8 ± 5.2 cm; $P = .444$). Finally, Villalta scores were estimated by review of clinic documentation, which may have led to an underestimation of PTS incidence.

CONCLUSIONS

Single-vs multiple-stage thrombolysis for DVT is not associated with a difference in extent of stent coverage. Patency rates remain high for iliac stenting irrespective of the number of lytic sessions, provided lysis is complete and the diseased segments are appropriately stented.

AUTHOR CONTRIBUTIONS

Conception and design: CG, RC, EA

Analysis and interpretation: CG, ZS, EA

Data collection: CG, ZS, YP, RC, ME, EH, MS, EA

Writing the article: CG, ZS, YP, EA

Critical revision of the article: CG, ZS, RC, ME, EH, MS, EA

Final approval of the article: CG, ZS, YP, RC, ME, EH, MS, EA

Statistical analysis: CG, ZS, EA

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Overall responsibility: EA

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