Improvement following restoration of inline flow argues against comprehensive thrombus removal strategies and for selective stenting in acute symptomatic iliofemoral venous thrombosis

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ABSTRACT

Objective: Randomized trials have demonstrated the benefit of thrombus removal strategies in iliofemoral deep venous thrombosis (IFDVT) in providing early symptom relief and decreasing the incidence of post-thrombotic syndrome (PTS), especially severe PTS. However, the impact of quantum of residual thrombus burden (RTB) on PTS as determined by intravascular ultrasound examination and the role of venous stenting in the acute setting have not been evaluated and represent the focus of this study.

Methods: Sixty-nine limbs (65 patients) undergoing thrombus removal for acute symptomatic IFDVT between 2015 and 2021 formed the study cohort. The Venous Clinical Severity Score (VCSS) (range, 0-27) grade of swelling (GOS) (range, 0-4), and visual analog scale (VAS) pain scores (range, 0-10) were evaluated initially and at 6, 12, and 24 months after thrombus removal. Quality of life was appraised using the CIVIQ-20 instrument. The extent of initial and RTB after the intervention was estimated using intravascular ultrasound examination. Grading was done as less than 50% (1), 50% to 99% (2), or 100% (3) of luminal thrombus fill within each segment (common femoral vein, external iliac vein, and common iliac vein) by a blinded rater and then combined to generate a total score. The use of stenting, both concurrent (severe residual stenosis/persistent occlusion) and delayed (quality of life impairing residual or recurrent symptoms), was evaluated.

Results: Of the 69 limbs, 53 underwent pharmacomechanical/mechanical thrombectomy (PMT), whereas 16 patients underwent PMT and catheter-directed thrombolysis with restoration of inline flow in all limbs. Post-intervention VCSS improved from 6 to 2 at 24 months ($P < .0001$). GOS improved from 4 to 0 at 24 months ($P < .0001$). The VAS pain score went from 5 to 0 at 6 months ($P < .0001$) and remained at 0 at 12 months ($P < .0001$), but increased to 3 at 24 months ($P = .02$). The CIVIQ-20 score improved from 38 to 22 ($P = .001$) over a median follow-up of 19 months. The median RTB total score improved from 9 to 4 ($P < .0001$). There was no impact of RTB total score (<3 vs >3) on VCSS ($P =$ NS), GOS ($P =$ NS), VAS pain score ($P =$ NS) or CIVIQ-20 score ($P =$ NS) at the various time points. Concurrent stenting was used in 23 limbs (33%) and delayed stenting was carried out in 10 limbs (14%). The median time to delayed stenting was 4 months after the initial thrombus removal intervention.

Conclusions: In patients undergoing PMT or PMT with catheter-directed thrombolysis for acute symptomatic IFDVT, the restoration of inline flow seems to be adequate to provide symptom relief and decrease the incidence of PTS. The extent of RTB does not seem to impact the VCSS, GOS, VAS pain score, or quality of life after such restoration. Stenting can be pursued selectively in the acute setting to help restore inline flow. (J Vasc Surg Venous Lymphat Disord 2023;11:119-26.)

Keywords: Chronic venous insufficiency; Deep venous thrombosis; Iliofemoral deep venous thrombosis; Mechanical thrombectomy; Pharmacomechanical thrombectomy; Post thrombotic syndrome

The annual incidence of deep venous thrombosis (DVT) in the United States has been estimated to be between 48 and 92 per 100,000.[1-3] Post-thrombotic syndrome (PTS), a constellation of symptoms and signs that arises after an episode of DVT, has been estimated to have a cumulative incidence of up to 50%, with a severe form occurring in approximately 9% of affected lower extremities.[4,5] The incidence of PTS is greater with involvement of the iliofemoral segment.[6] To decrease this high incidence of PTS, studies have looked at the use of thrombus removal strategies in addition to optimal medical therapy including therapeutic anticoagulation. Randomized control trials have demonstrated the benefit of thrombus removal strategies in the setting of iliofemoral DVT (IFDVT) in providing early symptom relief,[7] a decrease in the incidence of PTS,[8] especially moderate to severe PTS,[7] and improving venous disease-specific quality of life.[7,9] Although the Catheter-directed Venous Thrombolysis (CaVenT) and

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Author conflict of interest: none.

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The editors and reviewers of this article have no relevant financial relationships to disclose per the Journal policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

2213-333X

https://doi.org/10.1016/j.jvsv.2022.06.017

Ultrasound-Accelerated Catheter-Directed Thrombolysis Versus Anticoagulation for the Prevention of Post-Thrombotic Syndrome (CAVA) trials used catheter-directed thrombolysis (CDT) as the technique for thrombus removal, the Acute Venous Thrombosis: Thrombus Removal with Adjunctive Catheter- Directed Thrombolysis (ATTRACT) trial used either pharmacomechanical or mechanical thrombectomy (PMT) or a combination of PMT and CDT.[10-12] CDT is associated with an increased use of lytics and a greater risk of bleeding in addition to prolonged hospitalization, whereas PMT as a single session therapy may not necessarily yield complete thrombus retrieval. This poses an important question: Is complete removal of a thrombus within the iliofemoral segment necessary or is creation of a flow channel alone adequate? The CaVenT trial reported patency rate in the iliofemoral segment after CDT of 65.9% at 6 months and 74.7% at 25 months compared with 47.4% ($P = .12$) and 59.6% ($P = .28$) in the standard treatment group (anticoagulation and compression stockings) at 6 and 24 months, respectively.[13] At the end of 5 years, however, there was no significant difference in iliofemoral venous patency between the two groups, namely, 79.1% in the CDT group and 70.9% in the standard treatment group ($P = .218$).[13] A subgroup analysis of the ATTRACT trial found that less thrombus burden in the common femoral vein (CFV) (more compressibility of the vein on duplex ultrasound [DUS] examination) at 1 month was associated with less PTS overall, less moderate to severe PTS, and better quality of life, but this was not the case for the popliteal vein thrombus.[14] Neither the ATTRACT nor the CAVENT trial looked at the quantum of thrombus burden in the iliac segment at the end of the intervention and its relation to development of PTS. Although the CAVA trial compared successful lysis (restored patency of >90%) to unsuccessful lysis, they found that such success was not associated with a decreased PTS burden.[15] All three trials used venography to guide treatment. This study attempts to assess impact of intravascular ultrasound (IVUS) examination determined residual thrombus burden (RTB) on development of PTS. IVUS examination is more sensitive in detecting residual thrombus than venography.[16] Additionally, the study evaluates the necessity of iliofemoral stenting in the acute setting in terms of maintaining iliofemoral patency and preventing development of PTS.

METHODS

Study design. A single-center retrospective analysis of prospectively collected data from 2015 to 2021 was carried out. Patient consent was obtained for the procedure. Institutional review board approval was obtained for dissemination of deidentified patient data.

ARTICLE HIGHLIGHTS

- **Type of Research:** Single-center retrospective analysis of prospectively collected data
- **Key Findings:** In patients undergoing pharmacomechanical or mechanical thrombectomy with or without catheter-directed thrombolysis for acute symptomatic iliofemoral deep venous thrombosis restoration of inline flow determined by intravascular ultrasound examination seems to be adequate to provide symptomatic improvement and decrease the incidence of post-thrombotic syndrome. Stenting can be pursued selectively in such settings to help restore inline flow.
- **Take Home Message:** Improvement after restoration of inline flow determined by intravascular ultrasound examination argues against comprehensive thrombus removal strategies and for selective stenting in acute symptomatic iliofemoral venous thrombosis.

Setting. The RANE center is a tertiary center for management of venous and lymphatic disorders.

Participants. Patients who presented with acute IFDVT (within 3 weeks of symptom onset), with diagnosis confirmed using DUS examination, and who were candidates for anticoagulation and thrombolysis constituted the study group. Exclusion criteria included age less than 18 years, inability to tolerate procedure under general anesthesia owing to poor health, a personal or family history of major bleeding diathesis, or a positive pregnancy test.

Intervention and follow-up. Under general anesthesia, access was obtained under ultrasound guidance in the ipsilateral popliteal vein or femoral vein depending on the extent of thrombus burden and a 11F 10-cm sheath placed. A venogram was typically performed unless a contraindication existed. IVUS interrogation (Visions PV .035 digital IVUS catheter; Philips, Amsterdam, the Netherlands) was then pursued to define the extent and volume of thrombus burden across the popliteal, femoral, common femoral, external iliac, common iliac, and inferior vena cava segments as dictated by access. Initially, the device used for pharmacomechanical thrombectomy (PMT) was the Trellis-8 system (Covidien, Mansfield, MA) and the AngioJet Peripheral Thrombectomy system (Boston Scientific, Marlborough, MA), and subsequently the Indigo Aspiration System CAT12 (Penumbra Inc, Alameda, CA) once it became available and finally the Inari ClotTriever device (Inari Medical, Irvine, CA). Angioplasty typically using a 16- or 18-mm angioplasty balloon was carried out to macerate the thrombus

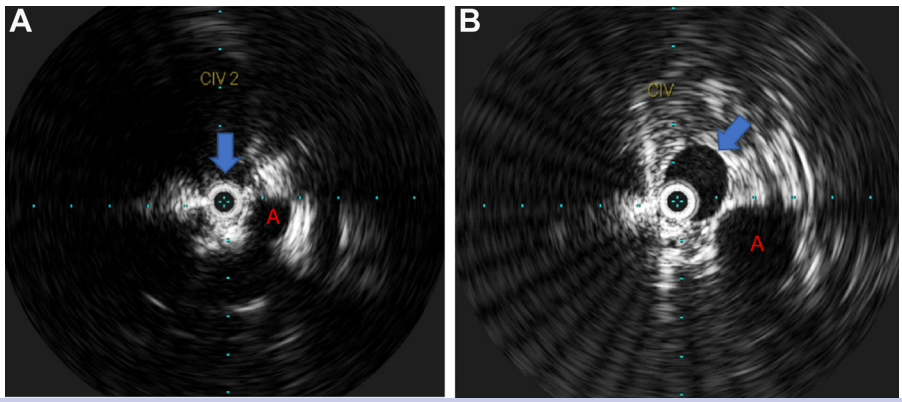

Fig 1. (A) Intravascular image of the common iliac vein demonstrating persistent flow limiting chronic stenosis post pharmacomechanical thrombectomy and balloon maceration. There is no flow channel visible around the IVUS catheter. This patient underwent stenting to restore inline flow. **(B)** Intravascular image of the common iliac vein demonstrating a patent flow channel post pharmacomechanical thrombectomy and balloon maceration. While this flow channel does not have a normal minimal luminal area and would be suggestive of chronic iliofemoral venous obstruction, in the acute setting such a channel is adequate. Such a patient does not require stenting in the acute setting. *A*, artery.

if the thrombectomy device was not successful in restoring inline flow. IVUS interrogation after mechanical thrombectomy and balloon maceration was used to determine restoration of inline flow. CDT was only used if there was significant RTB with absence of restoration of inline flow on IVUS examination despite the use of the measures discussed elsewhere in this article. Stenting was used selectively to facilitate restoration of inline flow if, after thrombus removal, there was a persistent flow-limiting chronic stenosis or persistent occlusion (concurrent stenting) (Fig 1). Delayed stenting was used on the development of symptomatic PTS not responding to conservative therapy during follow-up. Stents used were a composite Wallstent-Z stent combination or one of the dedicated venous stents, depending on surgeon preference. Inline flow restoration was defined using IVUS examination as the presence of a luminal channel involving the common femoral, external iliac, common iliac, and the inferior vena cava all the way to the right atrium.

Anticoagulation was started as soon as the initial diagnosis of DVT was made and continued as long as indicated by the inciting event. After the intervention, patients received a pair each of knee high compression wraps (20-30 mm Hg) with the recommendation for regular use. Follow-up included DUS examination, which was done at 3 weeks, 3 months, 6 months, and 12 months after stenting and yearly thereafter. If stents were not placed, then the patient had a DUS examination at 6 weeks then clinic visits alone at the 3-, 6- and 12-month marks after the intervention with subsequent follow-up dictated by necessity. The DUS data were analyzed to evaluate the patency of the iliofemoral segment and development of reflux. The venous segmental disease score—reflux (rVSDS) was used to define the latter. Details pertaining to technique of stenting, stent sizing and perioperative management have been described in prior publications.[17-21]

Characterization of RTB. Thrombus burden was assessed before and after thrombus removal using IVUS examination. The grading of luminal thrombus fill within each segment, CFV, external iliac vein, and common iliac vein, was scored as less than 50% (1), 50% to 99% (2), or 100% (3) by a rater blinded to the clinical status of the patient and adapted from Mewissen et al.[22] The scores for each segment were combined to generate a total score for each limb. This total score was assessed pre and post thrombus removal. The latter, RTB, was then grouped into two (total score of ≤ 3 and >3) and compared.

Evaluation of clinical parameters and quality of life. Clinical metrics evaluated included the Venous Clinical Severity Score (VCSS), grade of swelling (GOS), and visual analog scale (VAS) pain score. The VCSS was assessed before and after intervention (before stenting and at every follow-up clinic visit). This score was assessed after subtracting 3 points for compression, leaving a possible score between 0 and 27. GOS was objectively assessed and scored as 0 (no swelling), 1 (pitting, nonobvious swelling), 2 (visible ankle swelling), 3 (gross swelling involving the leg up to the knee), and 4 (gross swelling involving the entire leg including the thigh). The VAS for pain was scored from 0 (no pain) to 10 (the most severe pain). The Chronic Venous Insufficiency Quality of Life Questionnaire (CIVIQ-20) instrument was used to assess the quality of life, with a score of 100 indicating the worst possible quality of life and a

Table I. Demographic and perioperative characteristics of the entire cohort

	PMT (n = 53 limbs)	PMT + CDT (n = 16 limbs)
Age, years (median, range)	57 (18-86)	45 (25-68)
Male:female	18: 33	5: 9
Left:right:bilateral	28: 21: 2	7: 5: 2
BMI	31 (22-44)	29 (21-44)
Thrombophilia present	19 (37)	4 (29)
Dose of alteplase, mg	10 (5-10) n = 34 limbs	15 (10-20) n = 13 limbs
Estimated blood loss, mL	30 (30-300) n = 51 patients	30 (30-30) n = 14 patients
Days in hospital	4 (1-19) n = 51 patients	4 (2-35) n = 14 patients
Peak serum creatinine >2 mg/dL during hospital stay	3.3 (2.1-7) n = 4 patients	0
Device used		
AngioJet Zelante	30 (57)	15 (94)
Penumbra-Indigo	18 (34)	0 (0)
Inari ClotTriever	4 (7)	0 (0)
Trellis-8 system	1 (2)	1 (6)

BMI, Body mass index; *CDT*, catheter-directed thrombolysis; *PMT*, pharmacomechanical thrombectomy.
Values are median (range) or number (%).

score of 0 indicating the best possible quality of life.[23,24]

Reintervention. Reintervention was pursued if, on follow-up, patients developed quality-of-life-impairing symptoms despite optimal conservative therapy owing to the onset of PTS or stent malfunction. Such reintervention involved IVUS interrogation and correction of culprit native vein stenosis (PTS) or stent pathology (in-stent restenosis, stent compression, a combination of in-stent restenosis and stent compression or stent occlusion).

Statistical analyses. Statistical analysis was performed using Prism version 8 (GraphPad, San Diego, CA). The groups (≤3 and >3 RTB) were compared using the *t* tests and χ^2 test. A Kaplan-Meier analysis was used to assess stent patency post intervention. A *P* value of .05 or less was considered significant.

RESULTS

Of the 65 patients (69 limbs) who underwent intervention, 42 were women and 23 men. The median age was 56 years and the median body mass index of the entire cohort was 30.6. The right limb was the treated limb in 26 patients, and the left was intervened limb in 35 patients. Four patients had bilateral limb intervention for bilateral IFDVT. The median follow-up was 19 months. Data from before and after RTB were available in 58 limbs (22 limbs with an RTB of ≤3 and 36 limbs with an RTB of >3).

Peri-intervention characteristics. PMT was used in 53 limbs, and a combination of PMT and CDT was availed of in 16 limbs. Thrombolytics were used in 34 patients (66%) who underwent PMT. The median dose of alteplase was 10 mg in those undergoing PMT and 15 mg in those undergoing PMT plus CDT. For the entire cohort the median RTB score improved from a baseline score of 9 to 4 after the intervention ($P < .0001$). The median length of hospital stay was 4 days. Complications were noted in two patients, one who died from an unrelated cause and a second who developed an access site infection. Warfarin was used in four patients (6%), and a direct oral anticoagulant (DOAC) was used in 50 patients (77%). Enoxaparin alone was used in the remainder. Thrombophilia was noted in 23 of the 65 patients (35%). Baseline and peri-intervention characteristics are considered in Table I.

Clinical outcomes after the intervention. The VCSS score improved from 6 to 2 at 6 months ($P < .0001$) and remained at 2 at 12 months ($P < .0001$) and at 24 months ($P < .0001$). GOS improved from 4 to 1 at 6 months ($P < .0001$), decreased to 0 at 12 months ($P < .0001$), and remained at 0 at 24 months ($P < .0001$). The VAS pain score decreased from 5 to 0 at 6 months ($P < .0001$), remained at 0 at 12 months ($P = .0017$), and increased to 3 at 24 months ($P = .02$). Table II considers the breakdown of the VCSS, GOS, and VAS pain scores between the two groups (RTB ≤3 vs RTB >3).

Quality-of-life outcomes after the intervention. Overall quality of life as evaluated by the CIVIQ-20 score improved for the entire cohort from 38 to 22 ($P = .001$). When broken down by group, the RTB of 3 or less group had an improvement from 38 to 24 ($P = .25$), whereas the RTB of greater than 3 group had an improvement from 38 to 31 ($P = .05$). There was no significant

Table II. Comparison between the residual thrombus burden (*RTB*) score of ≤3 and >3 groups across Venous Clinical Severity Score (*VCSS*), grade of swelling (*GOS*), and visual analog scale (*VAS*) pain score before the intervention and at 6, 12 and 24 months after the intervention

	RTB ≤ 3	RTB > 3	*P* value
VCSS			
Pre-intervention	6	7	.30
6	2	2	.68
12	2	1.5	.94
24	2	2	.52
GOS			
Pre-intervention	4	4	.09
6	1	1	.50
12	0	1	.54
24	0	1	.23
VAS			
Pre-intervention	7	4	.10
6	0	0	.84
12	2	0	.29
24	3	3	.87

difference between the two scores either at baseline ($P = .48$) or at the last follow-up ($P = .92$).

Patterns of stenting and outcomes. Concurrent stenting was pursued in 23 limbs (33%). Delayed stenting was noted in 10 limbs (14%). This strategy was adopted either because of the development of PTS (5/10) or reocclusion (5/10). The median time to delayed stenting was 4 months. No stenting was required in 36 of the 69 limbs (53%). The breakdown of concurrent versus delayed versus no stenting in the two groups (RTB ≤3 vs RTB >3) is considered in Table III. At 24 months, the native iliofemoral segment had a patency of 72%, whereas the concurrent stented segment had a primary patency of 87%. Concurrent stent primary-assisted and secondary patencies were 100%. Stent patencies are considered in Fig 2. Reintervention in the two groups (RTB ≤3 vs RTB >3) is considered in Table IV.

DUS examination characteristics. At the last follow-up, DUS data were available for 58 of the 69 limbs (84%). Every one of these limbs—22 in the RTB of 3 or greater group and 36 in the RTB of less than 3 group—had a patent iliofemoral segment with median vein diameters of 12, 9, and 11 mm in the CFV, external iliac vein, common iliac vein, respectively (RTB ≤3 group) and 12, 9, and 10 mm the latter (RTB >3). Reflux data were available in 50 of the 69 limbs (72%). The RTB of 3 or greater group had deep venous reflux in 10 of 17 limbs (59%) with a median rVSDS of 1 (range, 0-2), whereas the RTB of 3 or greater group had deep venous reflux 20 of 33 limbs (61%) with a median rVSDS of 0 (range, 0-3).

DISCUSSION

The ATTRACT trial demonstrated the benefit of thrombus removal strategies in IFDVT in providing early symptom relief and in the reduction of PTS and its severity.[7] Additionally, the trial also found a greater improvement in disease specific quality of life post thrombus removal.[9] However, none of the randomized trials evaluated the impact of IVUS-determined quantum of RTB on PTS nor did they analyze the role of stenting in the acute setting.

RTB and inline flow. The relation between RTB and symptom relief, quality-of-life improvement, and risk of PTS is not well-defined in the literature. In the CaVenT trial the score used by Mewissen et al[8] was used to evaluate thrombus burden as it was in this study. The postulated goal was "complete lysis or ceased progression on venography" with a maximum duration of 96 hours. The breakdown of the number of limbs in whom these goals were achieved in the treatment arm is not mentioned. Additionally, the relation between attainment of the postulated goal and PTS or quality of life was not explored.[8,10] The ATTRACT trial also used before and after pharmacomechanical CDT (PCDT) venography to evaluate thrombus burden. The trial used the scoring system described by Marder et al.[7,11,25] The mean thrombus removal in the iliofemoral cohort was noted to be 86% (Marder score improving from 12 to 3; $P < .001$).[7] The original goal in the study had been at least 90% thrombus removal with restoration of flow unless a serious complication arose.[11] For the entire cohort the mean degree of thrombus removal was 76% (Marder score improving from 11.4 to 2.7; $P < .001$).[11] In the CAVA trial, venography was again used to evaluate thrombus burden. Thrombolysis was terminated when venous patency of 90% or more was attained, 48 hours without improvement of patency, persistence of deviance in coagulation status or when 96 hours (maximum duration of thrombolysis) was exceeded.[12] A subgroup analysis of the cohort where 90% or more patency was attained demonstrated a significant decrease in symptom severity and improved quality of life over those who did not undergo successful lysis.[15] This subgroups analysis, although not powered to evaluate the question at hand, nevertheless supports the open vein hypothesis vis a vis symptom and quality-of-life improvement. However, all three trials used venography and not IVUS examination. Using IVUS examination to determine residual thrombus is a more accurate way of ascertaining RTB and ensuring that restoration of inline flow truly occurs. In the ATTRACT trial, subgroup analysis by Weinberg et al[14] noted a noncompressible CFV at 1 month in the PCDT group of 21% that was not significantly different from the 35% noncompressible CFV in the control group. At 12 months while the noncompressible CFV proportion in the PCDT group remained at 21%, in the control group

Table III. Breakdown of concurrent versus delayed versus no stenting in the two groups (residual thrombus burden [*RTB*] ≤3 vs RTB >3)

	RTB ≤ 3 (n = 22)	RTB > 3 (n = 36)	*P* value
Concurrent stents	11 (50)	10 (28)	.09
Delayed stents	2 (9)	7 (19)	.31
No stents	9 (41)	19 (53)	.38

Values are number (%).

this increased to 39% ($P = .014$). These are findings are somewhat surprising. This high a proportion of noncompressibility in the CFV at 1 and 12 months, raises concern for significant RTB in the iliofemoral segment. (14) This is potentially reflective of the shortcomings of venography in accurately determining RTB and consequent possibility of worse outcomes. IVUS examination enables much better visualization of thrombus burden before and after intervention and is able to clearly demonstrate the presence of significant residual chronic stenosis and attainment of a flow channel across the iliofemoral venous segment after intervention.

Improvement after the restoration of inline flow. Restoration of inline flow as determined by IVUS examination was the underpinning factor in this study. With the accomplishment of this restoration, improvement in clinical parameters was noted. This improvement includes a 5-point improvement in the VCSS that persists at the 24-month mark. This improvement is noted for the GOS as well, with no swelling noted at the 6-, 12-, and 24-month time points. Although there was some recurrence in pain at 24 months, overall the VAS pain score was still much improved from baseline. Although cutoffs have not been established for the VCSS regarding PTS, it would be fair to say that a score of 2 would be mild PTS at best.[26] The development of severe PTS was not observed. A significant improvement in the quality of life was noted as well after the restoration of inline flow, with the CIVIQ-20 score improving from 38 to 22 ($P = .001$).

Impact of RTB score after the restoration of inline flow. An important question that needs to be posed is whether RTB matters once inline flow has been restored. This study finds that it does not. When the impact of RTB, using a modified version of the score described by Mewissen et al,[22] was assessed, there was no impact of RTB score (<3 vs >3) on the VCSS (P = NS), GOS (P = NS), VAS pain score (P = NS), or CIVIQ-20 score (P = NS) at 6, 12, or 24 months. This finding indicates that, once IVUS-determined restoration of inline flow occurs, it is quite likely that the autolytic capacity of the body and anticoagulation contribute to the improvement over time. This is to the extent that if PTS does occur, it is generally mild at best. This point argues against aggressive, comprehensive thrombus removal strategies that increases the risk of complications, including bleeding and acute kidney injury, as well as extending the duration of hospitalization.

Role of stenting. There is a school of thought that a more aggressive use of iliofemoral stenting in the acute setting could have contributed to better outcomes in

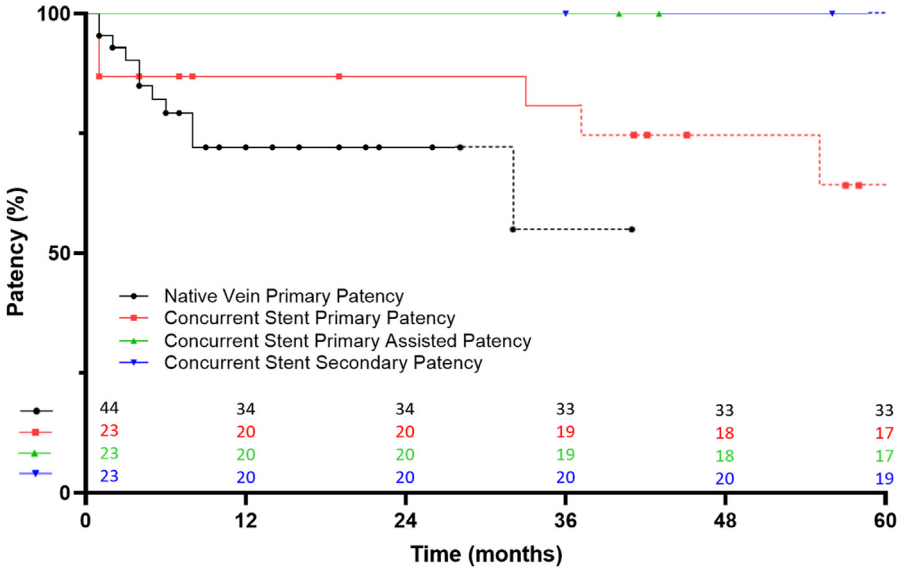

Fig 2. Plot depicting native vein and concurrent stent patencies (standard error of the mean of >10%: occurred at 28 months for the native vein primary patency; at 45 months for the concurrent stent primary patency; at 100 months for concurrent stent primary-assisted patency and at 58 months for concurrent stent secondary patency).

Table IV. Breakdown of reinterventions in those limbs that underwent concurrent stenting in the 2 groups (residual thrombus burden [*RTB*] ≤3 vs RTB >3)

	RTB ≤ 3 (n = 11)	RTB > 3 (n = 10)	*P* value
ISR	1 (9)	0 (0)	.34
ISR + SC	1 (9)	0 (0)	.34
Acute occlusion	0 (0)	3 (30)	.06
Chronic occlusion	0 (0)	1 (10)	.29
Total	2 (18)	4 (40)	.27

ISR, In-stent restenosis; *SC*, stent compression.
Acute occlusion was defined as when occurring ≤30 days post intervention and chronic occlusion beyond that. Values are number (%).

the randomized trials previously discussed.[27] However, such a finding is not supported in this study. Stenting must be seen as an adjunct to restore inline flow. To essentially correct the underlying chronic pathology that may have served as the basis for development of the acute DVT episode. Outside of this setting, stenting should be used in patients who develop PTS (7.1%) or who develop reocclusion (7.1%). In the study, 53% of limbs did not require stenting over the duration of follow-up, with a native vein patency of 72%. This point is important; not only does the native vein have a high patency following restoration of inline flow, additionally, stenting in the acute setting is associated with high rates of stent thrombosis (13% in the CAVA trial), compared with approximately 3% placed in the setting of chronic iliofemoral venous obstruction.[17,21,28] The overall stent occlusion rate was 5.7% in this study without impact from RTB score.

Future directions. The CaVenT, CAVA, and ATTRACT trials all used venography to confirm the diagnosis and make treatment decisions. Compared with venography, IVUS examination allows better evaluation of intraluminal characteristics including thrombus and allows for better ascertainment of adequacy of thrombus removal strategies. The open vein hypothesis in the iliofemoral segment is supported to varying degrees by the three trials. However, given the inclusion of femoropopliteal DVT as well, these trials were not powered to arrive at definitive conclusions regarding treatment strategies in the iliofemoral segment. In addition, because eventual treatment in patients with symptomatic PTS impairing their quality of life involves the correction of the iliofemoral venous obstruction, any study evaluating the development of PTS should evaluate the iliac segment for RTB. Thrombus burden in the common femoral or femoropopliteal segment is not an accurate surrogate for thrombus in the iliac segment. Additionally, all three trials used a vitamin K antagonist as the primary treatment modality for anticoagulation, with enoxaparin and DOAC having limited use. Recent data suggest that DOACs may be more effective than vitamin K antagonists in decreasing PTS.[29] Given this finding, future studies should focus on use of IVUS examination in conjunction with a standardized antithrombotic regimen with DOACs for the treatment of patients presenting with acute symptomatic iliofemoral venous thrombosis. There is much we do not know about improvements after an episode of DVT, including the precise role of the inflammatory cascade that occurs and impact of the DVT on lymphatic outflow. These need to be studied in greater depth to further hone our treatment of deep vein thrombosis.

Limitations. The inherent retrospective nature of the study and the small sample size represent shortcomings. Loss of patients to follow-up over time is an additional problem. Although loss to follow-up is a problem with most studies, the former problems can be overcome with larger, randomized trials that use IVUS examination to guide treatment. Although this study represents the first of its kind to quantify RTB using IVUS examination and relate it to the development of PTS and quality of life, much more work remains to be done in this regard.

CONCLUSIONS

In patients undergoing PMT for acute symptomatic IFDVT, the restoration of inline flow seems to be adequate to provide symptom improvement and decrease the incidence of PTS. The extent of RTB does not seem to impact VCSS, GOS, VAS pain score, or quality of life after such restoration. Stenting should be pursued selectively in the acute setting to help restore inline flow. Further study is required to confirm these findings.

AUTHOR CONTRIBUTIONS

Conception and design: AJ
Analysis and interpretation: AJ, ML
Data collection: AJ, ML, RF, TP, RK
Writing the article: AJ, ML, RF, TP, RK
Critical revision of the article: AJ
Final approval of the article: AJ, ML, RF, TP, RK
Statistical analysis: ML
Obtained funding: Not applicable
Overall responsibility: AJ

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Submitted May 10, 2022; accepted Jun 30, 2022.