

Endovascular Therapy for Post-Thrombotic Syndrome — A Randomized Trial

S. Vedantham,¹ S.R. Kahn,² W.A. Marston,³ I. Weinberg,⁴ A.K. Sista,⁵ E.A. Magnuson,⁶ D.J. Cohen,⁷ S.M. Wasan,⁸ M.K. Razavi,⁹ S.Z. Goldhaber,¹⁰ K.M. Sanfilippo,¹¹ A.J. Comerota,¹² E.M. Azene,¹³ C.I.O. Chaar,¹⁴ D.A. Leung,¹⁵ K.P. Kolli,¹⁶ S.P. Kalva,¹⁷ N. Rostambeigi,¹ A. Desai,¹⁸ K.R. Desai,¹⁹ A.J. Tafur,²⁰ B. Khalsa,⁹ E. Majerus,¹¹ B. Wang,²¹ Y. Wang,²¹ P. Nieters,¹ M.C. Derfler,¹ A. Oliver,¹ C. Hardy,¹ R. Bashir,²² R. Winokur,⁵ N. Weger,²³ M.S. Khaja,²⁴ A. Sharma,²⁵ N. Mani,¹ P. Kavali,¹ S. Thukral,²⁶ L.L. Lake,²⁷ K. Mikkelsen,²⁸ and S. Parpia,²¹ for the C-TRACT Trial Investigators*

ABSTRACT

BACKGROUND

Post-thrombotic syndrome is common after deep-vein thrombosis and can cause severe symptoms involving the limbs that impair patients' activity and quality of life. Endovascular therapy can eliminate chronic venous obstruction and is hypothesized to reduce the severity of post-thrombotic syndrome.

METHODS

We randomly assigned 225 patients with moderate or severe post-thrombotic syndrome and imaging-confirmed iliac-vein obstruction to receive endovascular therapy (iliac-vein stent placement and enhanced antithrombotic therapy) plus standard post-thrombotic syndrome care or standard post-thrombotic syndrome care alone. The severity of post-thrombotic syndrome at 6 months (the primary outcome) was assessed with the validated Venous Clinical Severity Score (VCSS) tool (scores range from 0 to 30, with higher scores indicating more severe post-thrombotic syndrome) by evaluators who were unaware of the group assignments. Key secondary outcomes included venous disease-specific and overall quality of life.

RESULTS

At 6 months, the severity of post-thrombotic syndrome was lower in the endovascular-therapy group than in the no-endovascular-therapy group (mean [±SD] VCSS, 8.1±5.1 vs. 10.0±4.9; adjusted difference, -2.0; $P=0.001$). Venous disease-specific quality of life as assessed with the Venous Insufficiency Epidemiological and Economic Study Quality of Life questionnaire was better in the endovascular-therapy group than in the no-endovascular-therapy group at 6 months (adjusted difference, 14.5 points; $P<0.001$), as was overall quality of life as assessed with the Medical Outcomes Study 36-Item Short-Form Health Status Survey physical component summary score (adjusted difference, 6.1 points; $P<0.001$); scores on both tools range from 0 to 100. Through 6 months, bleeding was more common in the endovascular-therapy group than in the no-endovascular-therapy group (in 11.6% vs. 3.6% of the patients; $P=0.03$).

CONCLUSIONS

Among patients with moderate or severe post-thrombotic syndrome and iliac-vein obstruction, endovascular therapy led to less severe post-thrombotic syndrome and better health-related quality of life than standard care over a 6-month period but with a higher risk of bleeding. (Funded by the National Heart, Lung, and Blood Institute and others; C-TRACT ClinicalTrials.gov number, NCT03250247.)

The authors' full names, academic degrees, and affiliations are listed at the end of the article. Suresh Vedantham can be contacted at vedanthams@wustl.edu or at the Mallinckrodt Institute of Radiology, Washington University School of Medicine, 510 S. Kingshighway Blvd., MSC 8131-43-1220, St. Louis, MO 63110.

*A full list of the investigators in the C-TRACT trial is provided in the Supplementary Appendix, available at NEJM.org.

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POST-THROMBOTIC SYNDROME FREQUENTLY develops after acute proximal deep-vein thrombosis (DVT).¹ Relatively few affected patients receive focused treatment for post-thrombotic syndrome owing to a lack of awareness among the medical community with regard to available therapies and a lack of evidence of clinical benefit for such therapies.² Venous hypertension plays a central role in post-thrombotic syndrome and stems from chronic venous obstruction, valvular reflux, elevation in central venous pressure, impairment of calf pump function, and lymphatic dysfunction.^{2,3} Post-thrombotic syndrome manifests across a broad severity spectrum; patients with post-thrombotic syndrome and iliac-vein obstruction often have chronic limb pain, swelling, skin changes, venous leg ulcers, or a combination of these symptoms, which impair function and quality of life.⁴

Previous studies have suggested that imaging-guided endovascular placement of metallic stents may reduce iliofemoral venous obstruction and thereby improve venous function, decrease the severity of post-thrombotic syndrome, and improve quality of life.⁵⁻⁹ However, the benefits and risks of such therapy are unclear. We conducted the C-TRACT (Chronic Venous Thrombosis: Relief with Adjunctive Catheter-Directed Therapy) trial to determine whether endovascular therapy would reduce the severity of post-thrombotic syndrome.

METHODS

TRIAL ORGANIZATION

The C-TRACT trial was a phase 3, multicenter, open-label, assessor-blinded, randomized, controlled trial sponsored by the National Institutes of Health.^{10,11} The trial was approved by a central institutional review board, and all the patients provided written informed consent. The C-TRACT steering committee was responsible for the design of the trial, and the C-TRACT investigators were responsible for the conduct of the trial. The authors were solely responsible for the writing of the manuscript and vouch for the completeness and accuracy of the data and for the fidelity of the trial to the protocol, which is available with the full text of this article at NEJM.org. The first author wrote the first draft of the manuscript, and the last author oversaw the analysis of the data by staff biostatisticians (see the Supplementary Appendix, available at NEJM.org).

PATIENT POPULATION

Patients with moderate or severe post-thrombotic syndrome and iliac-vein obstruction were enrolled at 29 clinical centers in the United States. Post-thrombotic syndrome was defined as the presence of chronic venous disease in the ipsilateral leg of a patient who had had DVT at least 3 months before enrollment.¹² Post-thrombotic syndrome was considered to be moderate or severe if the patient had substantial limitations in daily activities or work capacity owing to venous symptoms that resulted in a score of 8 or higher on the Venous Clinical Severity Score (VCSS) assessment tool, a score of 10 or higher on the Villalta post-thrombotic syndrome scale, or an open venous ulcer.¹²⁻¹⁶ Further details regarding the VCSS and Villalta scale tools are included in the description of the outcomes and assessments. Iliac-vein obstruction was defined as the presence of occlusion or at least 50% stenosis identified on catheter venography, intravascular ultrasonography (IVUS), computed tomographic venography, or magnetic resonance venography. Patients were excluded if they were younger than 18 years of age, were pregnant, or had had acute DVT within the previous 3 months, poor inflow to the common femoral vein, or previous stent placement. Details of the inclusion and exclusion criteria are provided in the Supplementary Appendix.

STRATIFICATION AND RANDOMIZATION

Patients were randomly assigned in a 1:1 ratio to receive either endovascular therapy (iliac-vein stent placement and enhanced antithrombotic therapy) or no endovascular therapy, with the use of a Web-based central randomization system. Randomization was stratified according to clinical center, the presence or absence of an open venous ulcer, and the status of the common femoral vein (normal or abnormal on ultrasonography) because the status of the common femoral vein affects the severity of post-thrombotic syndrome and stent patency.^{1,17,18} The randomization sequence, which was computer-generated in advance by an independent statistician with the use of varying block sizes, was not accessible to clinical center personnel. Trial-group assignments were concealed from trial personnel until their release.

TREATMENTS

Patients in both groups received standard care for post-thrombotic syndrome. This included individualized compression therapy (starting with sized-

to-fit, knee-high elastic compression stockings with a pressure of 20 to 30 mm Hg [Medi USA] for patients who had not previously used compression stockings) that was adjusted as needed to encourage adherence to their use; appropriate anticoagulant therapy that was selected on the basis of the patient's risk of DVT recurrence; guidance on smoking cessation, leg elevation, exercise, and avoidance of limb trauma; and, for patients with an open venous ulcer, encouragement to take oral pentoxifylline and to use multi-layer compression, along with referral to a wound and ulcer care clinic for comprehensive evidence-based care.^{2,19-23}

Endovascular therapy was performed according to published guidelines by board-certified physicians whose credentials were approved by the trial leadership.^{5,23} Sterile technique, fluoroscopic guidance, and either general anesthesia or moderate sedation were used. The treating physician chose the access vein, the method of crossing the obstructed veins, and the type of stent (which was required to be approved or cleared by the Food and Drug Administration for any indication, made of nitinol or elgiloy, noncovered, and ≥ 12 mm in diameter). After multiplanar catheter venography and IVUS were performed (as required), the veins were predilated and stents were deployed and dilated to at least 12 mm in diameter. Repeat venography and IVUS were performed. If acute thrombus or obstruction of venous inflow was present, standard endovascular methods were used to optimize flow. Patients received anticoagulation during endovascular therapy. After endovascular therapy, the use of therapeutic anticoagulants and daily aspirin (at a dose of 81 mg) was recommended for at least 6 months if the patient had no contraindications to either treatment.

OUTCOMES AND ASSESSMENTS

The primary outcome was the severity of post-thrombotic syndrome at 6 months after randomization, which was evaluated with the VCSS assessment tool by a clinician who was unaware of the trial-group assignments.¹³⁻¹⁵ Secondary efficacy outcomes were patient-reported quality of life, the severity of post-thrombotic syndrome as assessed on the Villalta scale, calf volume, and the presence of open venous ulcers. Safety outcomes were bleeding, symptomatic recurrent venous thromboembolism (VTE), and death.

The VCSS tool is a validated scoring system

that is designed to assess clinical change in patients with chronic venous diseases. The tool calculates scores for nine venous manifestations (eight clinical signs and one symptom) and for adherence to the use of compression therapy, each of which is given a score between 0 and 3; this results in a total score between 0 and 30. VCSS values, which are reported on a continuous scale and according to severity categories that correlate with markers of disease severity, have been used as a key outcome in post-thrombotic syndrome investigations.^{8,9,14,24-27} Blinded assessment with the Villalta post-thrombotic syndrome scale (scores range from 0 to 33) was used as a secondary measure of severity of post-thrombotic syndrome.^{12,16} On both scales, higher scores indicate more severe post-thrombotic syndrome.

Patient-reported quality of life was assessed at 6 months with the Venous Insufficiency Epidemiological and Economic Study Quality of Life (VEINES-QOL) questionnaire for venous disease-specific quality of life (scores range from 0 to 100; a change of 4 to 6 points is considered to be an important clinical change) and with the Medical Outcomes Study 36-Item Short-Form Health Status Survey (SF-36) for overall quality of life (scores range from 0 to 100; a change of 2.5 points is considered to be an important clinical change).²⁸⁻³³ On both scales, higher scores indicate better quality of life.

Calf volume was estimated with the use of the truncated-cone formula on the basis of measurements of calf circumference and length that were obtained at 6 months by an assessor who was unaware of the trial-group assignments.³⁴ The presence of an open venous ulcer at 6 months was also recorded by the assessor.

Independent core laboratory readers evaluated the venograms and IVUS images that were obtained during the endovascular therapy procedures before and after stenting. The iliac veins were graded as occluded, partially occluded ($\geq 50\%$ obstruction), or patent ($< 50\%$ obstruction).

Bleeding, symptomatic recurrent VTE, and deaths were adjudicated in a blinded manner by an independent committee. Bleeding was considered to be major if it was overt and prompted a decrease in the hemoglobin level of at least 2.0 g per deciliter, led to transfusion of 2 or more units of packed red cells, or involved a critical site.³⁵ Diagnosis of symptomatic recurrent VTE required the presence of new or worsening symptoms and imaging confirmation.

STATISTICAL ANALYSIS

The sample size was based on the hypothesis that there would be no difference between the groups in the mean VCSS at 6 months. On the basis of previous trial data from patients with a high baseline VCSS, we anticipated a 3-point mean decrease from baseline in the no-endovascular-therapy group with a standard deviation of 5.4 as compared with a 5-point mean decrease from baseline in the endovascular-therapy group with a standard deviation of 5.4.^{8,24} We calculated that a sample of 155 patients per group would provide the trial with 90% power to detect a 2-point mean difference between the groups, at a two-sided significance level of 0.05. After accounting for expected loss to follow-up (<5% of the patients), crossover from no endovascular therapy to endovascular therapy (<10%), and crossover from endovascular therapy to no endovascular therapy (<3%), the target sample size was increased by 20.6% to 374 patients (187 per group). Although the minimal clinically important difference in the VCSS has not been formally established, the 2-point mean difference that we aimed to detect was half the size of published VCSS score thresholds (4 points apart) that correlate with incremental gradations in clinical severity.¹⁴

In December 2023, an independent committee at the National Heart, Lung, and Blood Institute (NHLBI) reviewed the progress of the trial without having access to trial-group-specific data. Because the numbers of observed crossovers and losses to follow-up were lower than expected, the investigators were instructed by the NHLBI, with approval from the data and safety monitoring board, to stop accrual in June 2025 or when a revised sample size of 250 patients was reached, whichever came first. This approach was estimated to provide the trial with more than 80% power under unchanged assumptions of the treatment effect and variability.

The modified intention-to-treat population included all the patients who had undergone randomization, excluding any patients who did not meet inclusion criteria (e.g., patients who did not have moderate or severe post-thrombotic syndrome or did not have iliac-vein obstruction). In the analyses that were performed in the modified intention-to-treat population, data were analyzed according to the group to which each patient was assigned. The main analysis of the primary outcome — the comparison between the groups with respect to the mean VCSS score at 6 months

— was performed in the modified intention-to-treat population with the use of a linear mixed model with adjustment for baseline VCSS score, stratification factors (normal or abnormal common femoral vein and presence or absence of an open venous ulcer) as fixed effects, and adjustment for center as a random effect. Missing VCSS values were imputed with the use of multiple imputation, including age, sex, body-mass index (BMI), stratification factors, baseline VCSS, and Villalta score at 6 months. Sensitivity and subgroup analyses of the primary outcome are described in the Supplementary Appendix.

The analysis of scores on the VEINES-QOL questionnaire was performed with the use of the Bland system with an approach that was similar to that used for the analysis of the VCSS, with adjustment for baseline quality of life score, stratification factors, age, sex, and BMI (with multiple imputation that also incorporated baseline VCSS and baseline valvular reflux).³⁰ Scores on the SF-36 were calculated with standard algorithms; the physical component summary scores of the SF-36 were analyzed with the same approach as that used for the VEINES-QOL scores (with multiple imputation that also included baseline VCSS and employment status).³⁶ The mean calf volume, which was adjusted for baseline volume, was compared between the groups with methods that were similar to those used for the primary outcome (with multiple imputation that also included age, sex, BMI, stratification factors, and baseline valvular reflux). Villalta scores, which were adjusted for baseline score and stratification factors, were summarized with means and 95% confidence intervals (with multiple imputation that also included age, sex, BMI, baseline VCSS, and baseline valvular reflux). The percentage of patients with active ulceration (persistent or new) was compared between the groups with the Cochrane–Mantel–Haenszel test with adjustment for common femoral vein status (normal or abnormal) and the presence or absence of an open venous ulcer.

Safety outcomes were summarized according to incidence and were compared between the groups with the Cochrane–Mantel–Haenszel test with adjustment for common femoral vein status (normal or abnormal) and the presence or absence of an open venous ulcer. Risk ratios and corresponding 95% confidence intervals and P values were calculated.

The main analysis of the VCSS at 6 months

was tested at a two-sided significance level of 0.05. To account for multiple comparisons, the mean VEINES-QOL score and the mean SF-36 physical component summary score were tested at an alpha level of 0.05 in hierarchical fashion. The difference between the groups in the mean VEINES-QOL score was tested first, and the difference between the groups in the mean SF-36 physical component summary score was tested only if the P value for the between-group difference in the mean VEINES-QOL score was less than 0.05. No multiplicity adjustments were made for calf volume, the presence or absence of an open venous ulcer, or safety outcomes.

RESULTS

PATIENT CHARACTERISTICS

From July 2018 through June 2025, a total of 225 patients underwent randomization: 113 to the

endovascular-therapy group and 112 to the no-endovascular-therapy group (Fig. 1). One patient who had been assigned to receive endovascular therapy was withdrawn by the institutional review board and excluded from analysis by the adjudication committee after the patient was found not to have imaging-confirmed iliac-vein obstruction. The demographic and clinical characteristics of the trial groups were similar at baseline (Table 1). The enrolled population was similar to the general U.S. population of patients with moderate or severe post-thrombotic syndrome (Table S11 in the Supplementary Appendix).

PROTOCOL ADHERENCE, TREATMENTS, AND FOLLOW-UP

The use of compression therapy was similar in the two groups (Table 2 and Table S7). The percentage of patients who used antithrombotic medications was higher in the endovascular-therapy group

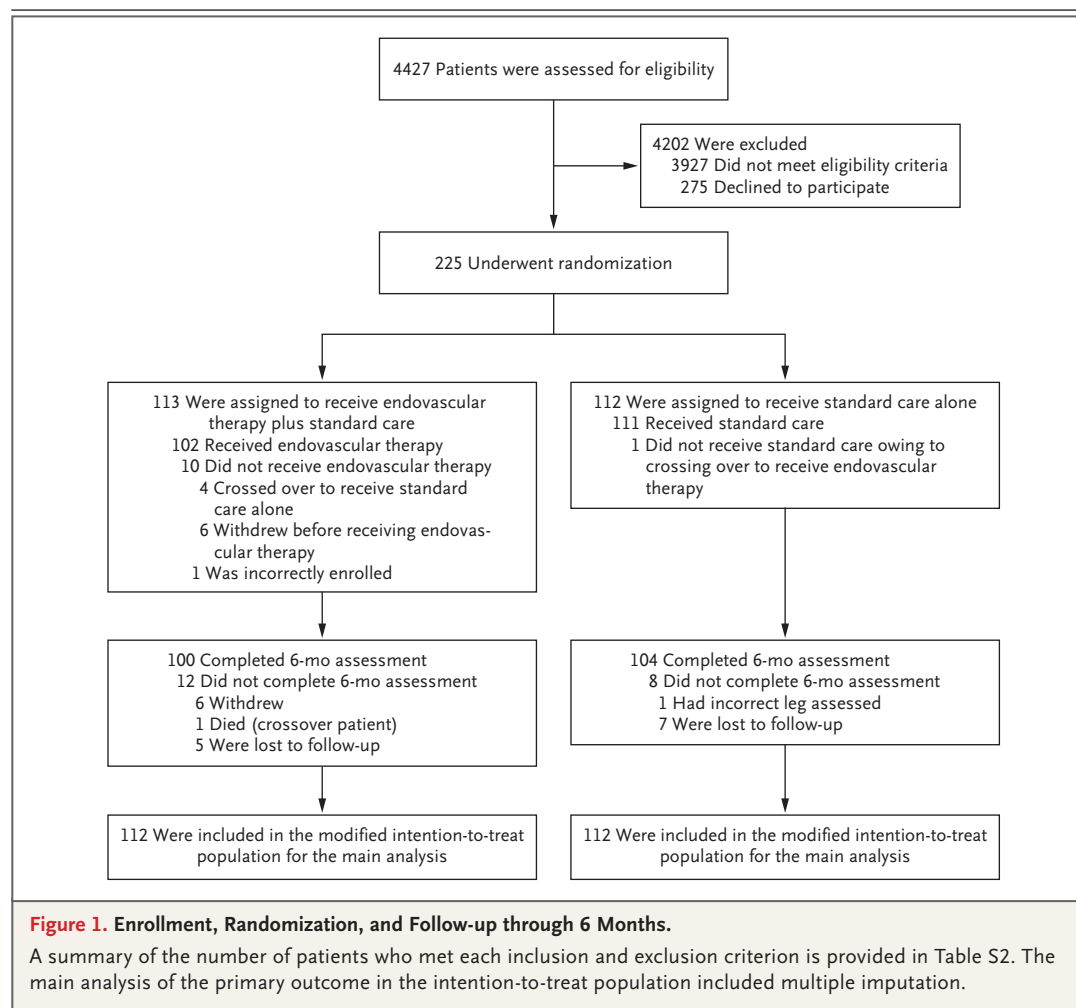


Table 1. Characteristics of the Patients at Baseline.*

Characteristics	Endovascular Therapy (N=112)	No Endovascular Therapy (N=112)
Age — yr	56.1±12.7	54.4±14.2
Female sex — no. (%)	52 (46.4)	54 (48.2)
Race — no. (%)†		
White	73 (65.2)	78 (69.6)
Black	31 (27.7)	23 (20.5)
Other	2 (1.8)	3 (2.7)
Data missing	6 (5.4)	8 (7.1)
Hispanic or Latino ethnic group — no. (%)‡	12 (10.7)	15 (13.4)
Body-mass index‡	35.0±8.3	35.3±8.3
Index post-thrombotic syndrome in left leg — no. (%)	75 (67.0)	81 (72.3)
CEAP clinical class — no. (%)§		
C2 or C3	25 (22.3)¶	22 (19.6)
C4	51 (45.5)‖	58 (51.8)
C5	19 (17.0)	16 (14.3)
C6	17 (15.2)	16 (14.3)
Normal common femoral vein — no. (%)	40 (35.7)	45 (40.2)
VCSS**	12.5±4.3	12.3±4.3
VEINES-QOL score††	38.9±20.9	39.6±24.1
Calf circumference — cm	43.9±8.3	43.3±6.0
Receipt of any anticoagulant medication — no. (%)	90 (80.4)	94 (83.9)
Receipt of any antiplatelet medication — no. (%)	29 (25.9)	20 (17.9)
Use of any compression therapy — no. (%)	94 (83.9)	83 (74.1)
Valvular reflux, any vein — no. (%)	88 (78.6)	92 (82.1)

* Plus-minus values are means ±SD. Percentages may not total 100 because of rounding.

† Race and ethnic group were reported by site personnel.

‡ Body-mass index is the weight in kilograms divided by the square of the height in meters.

§ The clinical, etiologic, anatomical, and pathophysiologic (CEAP) classification system ranges from C0 to C6, with higher classes associated with more severe clinical features of venous disease.

¶ Two patients were originally categorized as C0 and subsequently corrected to C3 because the edema subscore on the Venous Clinical Severity Score (VCSS) tool is nonzero.

‖ One patient was originally categorized as C2 and subsequently corrected to C4 because the pigmentation subscore on the VCSS tool is nonzero.

** VCSS total scores range from 0 to 30, with higher scores indicating more severe post-thrombotic syndrome.

†† Scores on the venous disease-specific Venous Insufficiency Epidemiological and Economic Study Quality of Life (VEINES-QOL) questionnaire range from 0 to 100, with higher scores indicating better quality of life.

than in the no-endovascular-therapy group, particularly with respect to antiplatelet agents (71.3% vs. 21.0%).

In the endovascular-therapy group, patients received endovascular therapy at a median of 16 days (interquartile range, 9 to 28) after randomization. Stent deployment was successful in 98 of 102 patients (96.1%). In 4 patients, the obstructed veins could not be crossed. On IVUS and venography, complete or partial iliac-vein obstruction

was present in 101 of 101 patients (100%) at the start of endovascular therapy procedures and in 14 of 101 patients (13.9%) at the end of these procedures. Complete occlusion was present in 52 of 101 patients (51.5%) at the start of the procedures and in 5 of 101 patients (5.0%) at the end of the procedures.

During the 6 months after randomization, 1 patient assigned to the no-endovascular-therapy group received endovascular therapy, and 4 pa-

Table 2. Treatments after Randomization.

Treatment	Endovascular Therapy (N=112)	No Endovascular Therapy (N=112)
Current treatments at 6 mo — no./total no. (%)		
Any anticoagulant medication	95/101 (94.1)	87/105 (82.9)
Any antiplatelet medication	72/101 (71.3)	22/105 (21.0)
Any compression therapy	93/99 (93.9)	97/103 (94.2)
Pentoxifylline	1/101 (1.0)	5/105 (4.8)
Any other venoactive medication	5/101 (5.0)	10/105 (9.5)
Any analgesic medication	26/101 (25.7)	28/105 (26.7)
Any superficial vein treatment in previous 6 months — no./total no. (%)	6/112 (5.4)	0/112 (0.0)
Index endovascular therapy procedure		
Index endovascular therapy procedure started — no./total no. (%)*	102/112 (91.1)	—
Index endovascular therapy procedure with successful stent placement — no./total no. (%)†	98/102 (96.1)	—
Mean no. of stents per patient (range)	2.1 (1.0–7.0)	—
Maximum stent diameter — mm	15.4±2.0	—
Minimum stent diameter — mm	14.0±2.0	—
Inferior vena cava stented — no./total no. (%)‡	19/102 (18.6)	—
Common iliac vein stented — no./total no. (%)‡	84/102 (82.4)	—
External iliac vein stented — no./total no. (%)‡	78/102 (76.5)	—
Common femoral vein stented — no./total no. (%)‡	51/102 (50.0)	—
Femoral vein stented — no./total no. (%)‡	1/102 (1.0)	—
Additional thrombolysis or thrombectomy — no./total no. (%)‡	3/102 (2.9)	—
Type of stent placed — no.‡		
Abre (Medtronic)	81	—
S.M.A.R.T. (Cordis)	13	—
Venovo (Becton Dickinson)	53	—
Vici (Boston Scientific)	12	—
Wallstent (Boston Scientific)	28	—
Zilver Vena (Cook Medical)	22	—
Unknown	3	—

* Data for the endovascular therapy procedure that was performed in the patient who crossed over from the no-endovascular-therapy group to the endovascular-therapy group are not included.

† The denominator is the number of patients in whom an index endovascular therapy procedure was started.

‡ Patients could be included in more than one category.

tients assigned to the endovascular-therapy group did not receive endovascular therapy (Fig. 1). Among these crossover patients, 1 patient in the endovascular-therapy group died before the 6-month assessment. Additional patients did not complete the 6-month assessment owing to loss to follow-up (12 patients), withdrawal (6 patients), or assessment of the incorrect leg (1 patient, who was excluded by the adjudication committee).

SEVERITY OF POST-THROMBOTIC SYNDROME

The severity of post-thrombotic syndrome at 6 months as assessed with the VCSS tool (the primary outcome) was significantly lower in the endovascular-therapy group than in the no-endovascular-therapy group (mean [±SD] VCSS, 8.1±5.1 vs. 10.0±4.9; adjusted difference, −2.0 points; 95% confidence interval [CI], −3.2 to −0.8; P=0.001) (Table 3). Similar results were seen in the sensi-

tivity analyses and across prespecified subgroups (Table S8 and Fig. S1). Point estimates of Villalta scores at 6 months also appeared to be lower in the endovascular-therapy group than in the no-endovascular-therapy group. Figure 2 shows the distribution of patients across the established VCSS and Villalta severity score categories at baseline and at 6 months.

SECONDARY EFFICACY OUTCOMES

At 6 months, the mean VEINES-QOL score was 62.8 ± 24.6 in the endovascular-therapy group as compared with 48.6 ± 26.7 in the no-endovascular-therapy group (adjusted difference, 14.5 points; 95% CI, 9.5 to 19.4; $P < 0.001$) (Table 3). The mean SF-36 physical component summary score was 56.0 ± 16.4 with endovascular therapy and 49.9 ± 17.1 with no endovascular therapy (adjusted difference, 6.1 points; 95% CI, 2.8 to 9.3; $P < 0.001$). The mean calf volume appeared to be similar in the two groups (2442.1 cm^3 in the endovascular-therapy group and 2392.2 cm^3 in the no-endovascular-therapy group), as did the percentage of patients with open venous ulcers (8.9% in the endovascular-therapy group and 9.8% in the no-endovascular-therapy group).

SAFETY OUTCOMES

Bleeding (major and nonmajor) was more common in the endovascular-therapy group than in the no-endovascular-therapy group (in 11.6% vs. 3.6% of the patients), a finding that was driven mainly by nonmajor bleeding (in 9.8% vs. 2.7%) (Table 3). Major bleeding was uncommon (occurring in four patients in the endovascular-therapy group and in one patient in the no-endovascular-therapy group) and included three patients with gastrointestinal bleeding and two patients with intraarticular bleeding. All the episodes of major bleeding in the endovascular-therapy group occurred more than 90 days after the endovascular therapy procedure. No episodes of bleeding were fatal or led to open surgical therapy (Table S3).

Both the incidence of symptomatic recurrent VTE and the incidence of death were similar in the two groups. One patient died from unknown causes at 5 months; the patient had been assigned to the endovascular-therapy group but did not receive endovascular therapy owing to personal choice and unrelated life events. Procedure-related serious adverse events included stent deformation

in one patient, which was corrected during the procedure with balloon angioplasty, and groin pain resulting in hospitalization in one patient (Table S4).

DISCUSSION

In this trial, a strategy of endovascular iliac-vein stenting that included additional antithrombotic therapy resulted in less severe post-thrombotic syndrome and better venous disease–specific and overall health-related quality of life at 6 months than standard care alone in patients with moderate or severe post-thrombotic syndrome and iliac-vein obstruction. The mean changes in the VCSS and Villalta scores associated with the use of endovascular therapy align with the results seen in prospective, single-group studies.^{25–27} A 2018 single-center, double-blind, randomized, controlled trial involving 51 patients in Brazil showed more improvement in VCSS and SF-36 scores after iliac-vein stenting than a sham procedure.⁸ A 2023 single-center, open-label, randomized, controlled trial that was conducted in Europe and involved 63 patients showed greater improvement in VCSS, VEINES-QOL, and Villalta scores with the addition of iliac-vein stenting than with best medical therapy alone.⁹

The C-TRACT trial confirms these findings in a larger trial with broad multisite involvement, precautions against bias, and a focus on post-thrombotic syndrome (as opposed to mixed venous disease, which was evaluated in earlier trials). Although the observed difference between the groups in the mean VCSS is of modest size, many of the patients' scores shifted to lower severity categories on the post-thrombotic syndrome scales over a 6-month period, a finding that was indicative of reduced life interference from venous disease.^{12–16} The 14.5-point between-group difference in venous disease–specific quality of life exceeds the change reported with catheter intervention in patients with acute iliofemoral DVT, and the 6.1-point difference in the SF-36 physical component summary score compares favorably with the differences reported for beneficial interventions in patients with other procedures, such as transcatheter aortic-valve replacement and catheter intervention for acute iliofemoral DVT.^{37–39} These findings highlight the value of iliac-vein outflow after DVT, which is in alignment with the open-vein hypothesis.⁴⁰

Table 3. Outcomes.*

Outcome	Endovascular Therapy (N=112)	No Endovascular Therapy (N=112)	Adjusted Difference or Risk Ratio (95% CI)†‡	P Value
Continuous‡				
Primary outcome				
VCSS§	8.1±5.1	10.0±4.9	-2.0 (-3.2 to -0.8)	0.001
Secondary outcomes				
VEINES-QOL score¶	62.8±24.6	48.6±26.7	14.5 (9.5 to 19.4)	<0.001
SF-36 physical component summary score	56.0±16.4	49.9±17.1	6.1 (2.8 to 9.3)	<0.001
Villalta score**	8.2±5.7	12.3±6.4	-4.1 (-5.5 to -2.7)	—
Calf volume — cm³††	2442.1±907.0	2392.2±849.6	-21.6 (-152.0 to 108.7)	—
Binary				
Secondary outcome				
Open venous ulcer — no. (%)	10 (8.9)	11 (9.8)	0.84 (0.42 to 1.71)	—
New ulcer	4 (3.6)	1 (0.9)	—	—
Persistent ulcer	6 (5.4)	10 (8.9)	—	—
Safety outcomes				
Symptomatic recurrent VTE — no. (%)	3 (2.7)	4 (3.6)	0.76 (0.17 to 3.28)	—
Stent thrombosis and other proximal DVT	3 (2.7)	0	—	—
Stent thrombosis only	1 (0.9)	0	—	—
Other proximal DVT only	0	4 (3.6)	—	—
Symptomatic pulmonary embolism	0	1 (0.9)	—	—
All bleeding — no. (%)	13 (11.6)	4 (3.6)	3.22 (1.07 to 9.69)	0.03
Major bleeding	4 (3.6)	1 (0.9)	4.01 (0.46 to 34.97)	—
Nonmajor bleeding	11 (9.8)	3 (2.7)	3.64 (1.02 to 12.93)	—
Death — no. (%)	1 (0.9)	0	—	—

* Plus-minus values are means ±SD. DVT denotes deep-vein thrombosis, and VTE venous thromboembolism.

† Adjusted differences in the mean scores, with 95% confidence intervals, were calculated for the continuous outcomes, and risk ratios with 95% confidence intervals were calculated for the binary outcomes.

‡ Analysis results for all the continuous outcomes were derived from multiply imputed datasets, with missing values imputed with the use of multiple-imputation methods. Outcome summaries of means and standard deviations were pooled across multiply imputed datasets by averaging group-specific means and within-imputation variances. The analyses of VCSS values, Villalta scores, and calf volume were adjusted for baseline value and stratification factors (normal or abnormal common femoral vein and the presence or absence of an open venous ulcer). The analyses of VEINES-QOL scores and Medical Outcomes Study 36-Item Short Form Health Survey (SF-36) physical component summary scores were adjusted for baseline quality-of-life score, stratification factors, age, sex, and body-mass index (BMI). Center has been treated as a random effect in all the models.

§ The multiple-imputation model included age, sex, BMI, stratification factors, baseline VCSS, and Villalta score at 6 months.

¶ The multiple-imputation model included baseline quality-of-life score, stratification factors, age, sex, BMI, baseline VCSS, and baseline valvular reflux.

|| The SF-36 includes a physical component summary score. Scores range from 0 to 100, with higher scores indicating better quality of life. The multiple-imputation model included baseline quality-of-life score, stratification factors, age, sex, BMI, baseline VCSS, and employment status.

** The Villalta scale is an assessment of five patient-reported symptoms and six venous-disease signs, which were reported by clinicians who were unaware of the trial-group assignments; a leg with an ulcer was assigned a minimum score of 15 points. Total scores range from 0 to 33, with higher scores indicating more severe post-thrombotic syndrome. The multiple-imputation model included baseline Villalta score, stratification factors, age, sex, BMI, baseline VCSS, and baseline valvular reflux.

†† Calf volume was calculated with the use of the formula for a truncated cone. The multiple-imputation model included baseline volume, stratification factors, age, sex, BMI, and baseline valvular reflux.

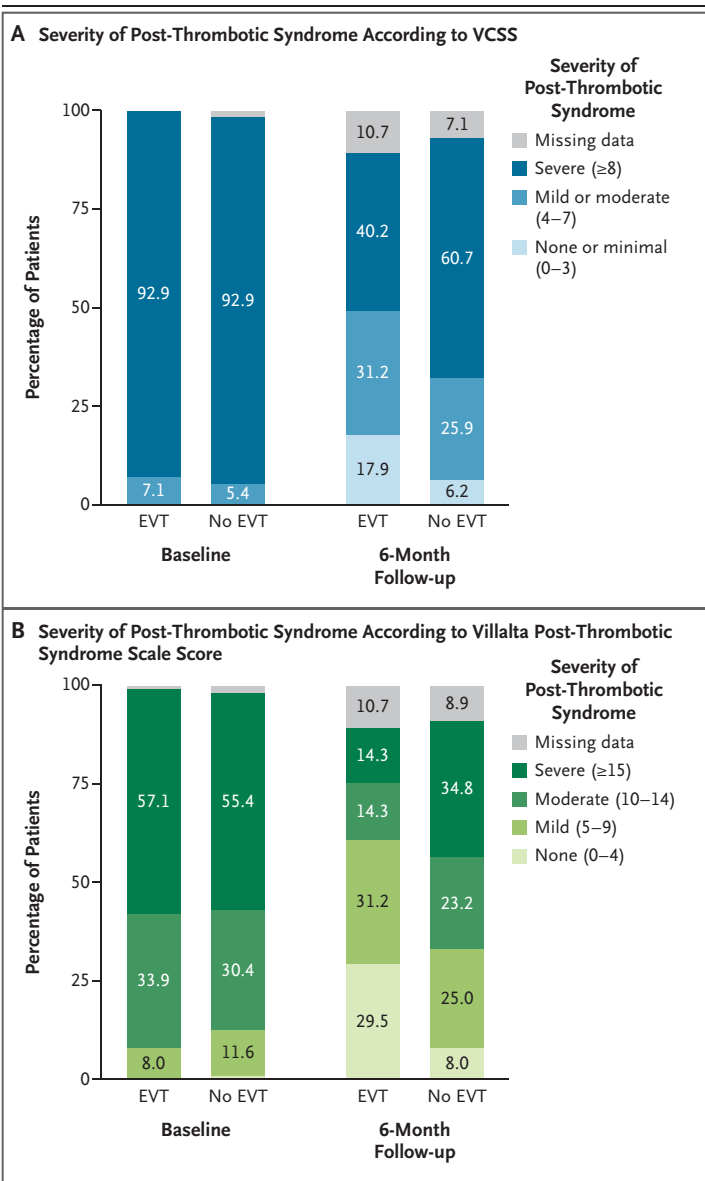


Figure 2. Categorical Distribution of VCSS and Villalta Scores.

Panel A shows the distribution of patients at baseline and at the 6-month follow-up according to the three established severity categories for post-thrombotic syndrome scores on the Venous Clinical Severity Score (VCSS) assessment tool: no or minimal post-thrombotic syndrome (0 to 3), mild or moderate post-thrombotic syndrome (4 to 7),^{4–7} and severe post-thrombotic syndrome (≥ 8).¹⁴ The VCSS total score ranges from 0 to 30, with higher scores indicating more severe post-thrombotic syndrome. Baseline VCSS values were missing for 2 patients (1.8%) in the no-endovascular-therapy group. Panel B shows the distribution of patients at baseline and at the 6-month follow-up according to the four established severity categories on the Villalta post-thrombotic syndrome scale: no post-thrombotic syndrome (0 to 4), mild post-thrombotic syndrome (5 to 9),^{5–9} moderate post-thrombotic syndrome (10 to 14),^{10–14} and severe post-thrombotic syndrome (≥ 15).^{12,16} The Villalta scale is an assessment of five patient-reported symptoms and six venous-disease signs, which were reported by clinicians who were unaware of the trial-group assignments; a leg with an ulcer was assigned a minimum score of 15 points. Total scores on the Villalta scale range from 0 to 33, with higher scores indicating more severe post-thrombotic syndrome. Baseline Villalta scores were missing for 1 patient (0.9%) in the endovascular-therapy group and for 2 patients (1.8%) in the no-endovascular-therapy group. Patients entered the trial with moderate or severe post-thrombotic syndrome, but over a period of 6 months, many of the patients' scores shifted to less severe categories, especially in the endovascular-therapy (EVT) group.

The high use of compression therapy, anticoagulation, and on-label venous stents should increase confidence that contemporary post-thrombotic syndrome care was provided, although higher use of antithrombotic therapy was seen in the endovascular-therapy group. Enhanced antithrombotic therapy to promote stent patency is common in real-world care with endovascular therapy and was integrated into the protocol, which resulted in the combined use of antiplatelet and anticoagulant medications in most of the patients in the endovascular-therapy group. Although most of the episodes of bleeding were nonmajor and occurred months after endovascular therapy, an increased risk of bleeding associ-

ated with enhanced antithrombotic therapy is a clinical trade-off of adopting a stent placement strategy.

This trial has limitations. First, to enable quality standard care for post-thrombotic syndrome and reflect real-world practice, the protocol provided guidance but allowed local physician-directed care. Variability in the care that was delivered could have affected outcomes, including the higher use of antithrombotic medications and superficial vein treatments in the endovascular-therapy group than in the no-endovascular-therapy group and the higher use of venoactive medications in the no-endovascular-therapy group. Second, the C-TRACT trial included facilities of various sizes, but these findings may not apply to endovascular therapy performed by less experienced operators. Third, follow-up beyond 6 months is needed to characterize the extended risk-benefit ratio of endovascular therapy, elucidate relationships between anatomical and clinical outcomes,

and further explore the use of endovascular therapy in patients with venous ulcers.

A fourth limitation is that the target sample size was reduced after reassessment indicated that our initial assumptions were overly conservative; final enrollment reached 90% of the revised target. Although the C-TRACT trial was substantially larger than previous randomized, controlled trials in which venous stents were evaluated, the reduced sample size decreased the precision of the treatment-effect estimates. This could have led to overestimation of benefit and underdetection of rare adverse events. Fifth, in an open-label trial, patient-reported quality of life is susceptible to expectation or performance bias. However, bias was minimized in this trial by blinded assessment of the scores on the VCSS tool, which includes mostly objective clinical signs that can be evaluated as opposed to subjectively reported symptoms. VCSS assessment was standardized through required assessor training and provision of the published scoring rubric.¹⁵

In this trial involving patients with moderate or severe post-thrombotic syndrome and iliac-vein obstruction, the addition of endovascular therapy to standard care for post-thrombotic syndrome resulted in less severe post-thrombotic syndrome and better health-related quality of life than standard care alone over a period of 6 months but led to a higher risk of bleeding.

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AUTHOR INFORMATION

Suresh Vedantham, M.D.,¹ Susan R. Kahn, M.D.,² William A. Marston, M.D.,³ Ido Weinberg, M.D.,⁴ Akhilesh K. Sista, M.D.,⁵ Elizabeth A. Magnuson, Sc.D.,⁶ David J. Cohen, M.D.,⁷ Suman M. Wasan, M.D., Pharm.D.,⁸ Mahmood K. Razavi, M.D.,⁹ Samuel Z. Goldhaber, M.D.,¹⁰ Kristen M. Sanfilippo, M.D., M.P.H.S.,¹¹ Anthony J. Comerota, M.D.,¹² Ezana M. Azene, M.D., Ph.D.,¹³ Cassius Iyad Ochoa Chaar, M.D., M.P.H.,¹⁴ Daniel A. Leung, M.D.,¹⁵ K. Pallav Kolli, M.D.,¹⁶ Sanjeeva P. Kalva, M.D.,¹⁷ Nassir Rostambeigi, M.D., M.P.H.,¹ Ajinkya Desai, M.D.,¹⁸ Kush R. Desai, M.D.,¹⁹ Alfonso J. Tafur, M.D.,²⁰ Bhavraj Khalsa, M.D.,⁹ Elaine Majerus, M.D., Ph.D.,¹¹ Borong Wang, M.Sc.,²¹ Yang Wang, M.Sc.,²¹ Patricia Nieters, R.N., B.S.N.,¹ Mary Clare Derfler, R.N., M.S.N.,¹ Angela Oliver, R.N., B.S.N., M.S.,¹ Cassandra Hardy, R.N., B.S.N.,¹ Riyaz Bashir, M.D., M.B., B.S.,²² Ronald Winokur, M.D.,⁵ Natalie Weger, D.O.,²³ Minhaj S. Khaja, M.D.,²⁴ Aditya Sharma, M.D.,²⁵ Naganathan Mani, M.D.,¹ Pavan Kavali, M.D.,¹ Siddhant Thukral, M.D., M.S.C.I.,²⁶ Leslie L. Lake, B.S.,²⁷ Kathryn Mikkelsen, M.B.A.,²⁸ and Sameer Parpia, Ph.D.²¹

¹Mallinckrodt Institute of Radiology, Washington University School of Medicine, St. Louis; ²McGill University, Jewish General Hospital, Montreal; ³University of North Carolina School of Medicine, Chapel Hill; ⁴Massachusetts General Hospital, Harvard Medical School, Boston; ⁵NewYork-Presbyterian-Weill Cornell Medical Center, New York; ⁶Saint Luke's Mid America Heart Institute, University of Missouri-Kansas City School of Medicine, Kansas City; ⁷Cardiovascular Research Foundation, New York; ⁸Wake Forest University School of Medicine, Winston-Salem, NC; ⁹St. Joseph Heart and Vascular Center, Orange, CA; ¹⁰Brigham and Women's Hospital, Harvard Medical School, Boston; ¹¹Washington University School of Medicine, St. Louis; ¹²Inova Alexandria Hospital, Alexandria, VA; ¹³Emplify Health, La Crosse, WI; ¹⁴Yale University School of Medicine, New Haven, CT; ¹⁵Christiana Hospital, Newark, DE; ¹⁶University of California, San Francisco, San Francisco; ¹⁷University of Texas Southwestern Medical Center, Dallas; ¹⁸University of Mississippi Medical Center, Jackson; ¹⁹Northwestern University, Chicago; ²⁰Endeavor Health Evanston Hospital, Evanston, IL; ²¹McMaster University, Hamilton, ON, Canada; ²²Mayo Clinic, Jacksonville, FL; ²³University of Iowa Health Care Medical Center, Iowa City; ²⁴University of Michigan, Ann Arbor; ²⁵Atrium Health, Charlotte, NC; ²⁶Duke University Medical Center, Durham, NC; ²⁷National Blood Clot Alliance, Philadelphia; ²⁸Vascularearn Network, Boston.

REFERENCES

1. Kahn SR, Shrier I, Julian JA, et al. Determinants and time course of the post-thrombotic syndrome after acute deep venous thrombosis. *Ann Intern Med* 2008;149:698-707.
2. Kahn SR, Comerota AJ, Cushman M, et al. The postthrombotic syndrome: evidence-based prevention, diagnosis, and treatment strategies: a scientific statement from the American Heart Association. *Circulation* 2014;130:1636-61.
3. Fukaya E, Kolluri R. Nonsurgical management of chronic venous insufficiency. *N Engl J Med* 2024;391:2350-9.
4. Kahn SR, Shbaklo H, Lamping DL, et al. Determinants of health-related quality of life during the 2 years following deep vein thrombosis. *J Thromb Haemost* 2008; 6:1105-12.
5. Vedantham S, Weinberg I, Desai KR, et al. Society of Interventional Radiology Position Statement on the management of chronic iliofemoral venous obstruction with endovascular placement of metallic

- stents. *J Vasc Interv Radiol* 2023;34(10):1643-1657.e6.
6. Razavi MK, Jaff MR, Miller LE. Safety and effectiveness of stent placement for iliofemoral venous outflow obstruction: systematic review and meta-analysis. *Circ Cardiovasc Interv* 2015;8(10):e002772.
7. Delis KT, Bjarnason H, Wennberg PW, Rooke TW, Gliviczki P. Successful iliac vein and inferior vena cava stenting ameliorates venous claudication and improves venous outflow, calf muscle pump function, and clinical status in post-thrombotic syndrome. *Ann Surg* 2007;245:130-9.
8. Rossi FH, Kambara AM, Izukawa NM, et al. Randomized double-blinded study comparing medical treatment versus iliac vein stenting in chronic venous disease. *J Vasc Surg Venous Lymphat Disord* 2018;6:183-91.
9. Shekarchian S, Van Laanen J, Esmail Barbaty M, et al. Quality of life after stenting for iliofemoral venous obstruction: a randomised controlled trial with one year follow up. *Eur J Vasc Endovasc Surg* 2023;66:678-85.
10. Vedantham S, Kahn SR, Goldhaber SZ, et al. Endovascular therapy for advanced post-thrombotic syndrome: proceedings from a multidisciplinary consensus panel. *Vasc Med* 2016;21:400-7.
11. Vedantham S, Parpia S, Kahn SR. A clinical trial of venous stent placement for post-thrombotic syndrome: current status and pandemic-related changes. *Vasc Endovasc Rev* 2022;5:e06.
12. Kahn SR, Partsch H, Vedantham S, Prandoni P, Kearon C. Definition of post-thrombotic syndrome of the leg for use in clinical investigations: a recommendation for standardization. *J Thromb Haemost* 2009;7:879-83.
13. Rutherford RB, Padberg FT Jr, Comerota AJ, Kistner RL, Meissner MH, Moneta GL. Venous severity scoring: an adjunct to venous outcome assessment. *J Vasc Surg* 2000;31:1307-12.
14. Meissner MH, Natiello C, Nicholls SC. Performance characteristics of the venous clinical severity score. *J Vasc Surg* 2002;36:889-95.
15. Vasquez MA, Rabe E, McLafferty RB, et al. Revision of the venous clinical severity score: venous outcomes consensus statement: special communication of the American Venous Forum Ad Hoc Outcomes Working Group. *J Vasc Surg* 2010;52:1387-96.
16. Kahn SR. Measurement properties of the Villalta scale to define and classify the severity of the post-thrombotic syndrome. *J Thromb Haemost* 2009;7:884-8.
17. Weinberg I, Vedantham S, Salter A, et al. Relationships between the use of pharmacomechanical catheter-directed thrombolysis, sonographic findings, and clinical outcomes in patients with acute proximal DVT: results from the ATTRACT multicenter randomized trial. *Vasc Med* 2019;24:442-51.
18. Jalaie H, Barbaty ME, Piao L, et al. Prognostic value of a classification system for iliofemoral stenting in patients with chronic venous obstruction. *Eur J Vasc Endovasc Surg* 2025;69:315-22.
19. Kearon C, Akl EA, Ornelas J, et al. Antithrombotic therapy for VTE disease: CHEST guideline and expert panel report. *Chest* 2016;149:315-52.
20. Ortel TL, Neumann I, Ageno W, et al. American Society of Hematology 2020 guidelines for management of venous thromboembolism: treatment of deep vein thrombosis and pulmonary embolism. *Blood Adv* 2020;4:4693-738.
21. O'Donnell TF Jr, Passman MA, Marston WA, et al. Management of venous leg ulcers: clinical practice guidelines of the Society for Vascular Surgery and the American Venous Forum. *J Vasc Surg* 2014;60:Suppl:3S-59S.
22. Jull AB, Arroll B, Parag V, Waters J. Pentoxifylline for treating venous leg ulcers. *Cochrane Database Syst Rev* 2012;12:CD001733.
23. Jaff MR, McMurtry MS, Archer SL, et al. Management of massive and submassive pulmonary embolism, iliofemoral deep vein thrombosis, and chronic thromboembolic pulmonary hypertension: a scientific statement from the American Heart Association. *Circulation* 2011;123:1788-830.
24. Vedantham S, Goldhaber SZ, Julian JA, et al. Pharmacomechanical catheter-directed thrombolysis for deep-vein thrombosis. *N Engl J Med* 2017;377:2240-52.
25. Razavi MK, Black S, Gagne P, Chiacchierini R, Nicolini P, Marston W. Pivotal study of endovenous stent placement for symptomatic iliofemoral venous obstruction. *Circ Cardiovasc Interv* 2019;12(12):e008268.
26. Hofmann LR, Gagne P, Brown JA, Saunders A, Comerota A. Twelve-month end point results from the evaluation of the Silver Vena venous stent in the treatment of symptomatic iliofemoral venous outflow obstruction (VIVO clinical study). *J Vasc Surg Venous Lymphat Disord* 2023;11(3):532-541.e4.
27. Black S, Sapoval M, Dexter DJ, et al. Three-year outcomes of the Abre Venous Self-Expanding Stent System in patients with symptomatic iliofemoral venous outflow obstruction. *J Vasc Interv Radiol* 2024;35(5):664-675.e5.
28. Lamping DL, Schroter S, Kurz X, Kahn SR, Abenham L. Evaluation of outcomes in chronic venous disorders of the leg: development of a scientifically rigorous, patient-reported measure of symptoms and quality of life. *J Vasc Surg* 2003;37:410-9.
29. Kahn SR, Lamping DL, Ducruet T, et al. VEINES-QOL/Sym questionnaire was a reliable and valid disease-specific quality of life measure for deep venous thrombosis. *J Clin Epidemiol* 2006;59:1049-56.
30. Bland JM, Dumville JC, Ashby RL, et al. Validation of the VEINES-QOL quality of life instrument in venous leg ulcers: repeatability and validity study embedded in a randomised clinical trial. *BMC Cardiovasc Disord* 2015;15:85.
31. Ware JE, Kosinski M, Keller S. SF-36 physical and mental summary measures: a user's manual. Boston: New England Medical Center, 1994.
32. Wywrich KW, Spertus JA, Kroenke K, Tierney WM, Babu AN, Wolinsky FD. Clinically important differences in health status for patients with heart disease: an expert consensus panel report. *Am Heart J* 2004;147:615-22.
33. Determining important differences in scores. In: Ware J, Kosinski M, Bjorner JB, Turner-Bowker DM, Gandek B, Maruish ME. User's manual for the SF-36v2 health survey. 2nd ed. London: Quality Metric, 2007.
34. Perrin M, Guex JJ. Edema and leg volume: methods of assessment. *Angiology* 2000;51:9-12.
35. Schulman S, Kearon C, Subcommittee on Control of Anticoagulation of the Scientific and Standardization Committee of the International Society on Thrombosis and Haemostasis. Definition of major bleeding in clinical investigations of antihemostatic medicinal products in non-surgical patients. *J Thromb Haemost* 2005;3:692-4.
36. Streiner DL, Norman GR. Health measurement scales: a practical guide to their development and use. 2nd ed. Oxford, United Kingdom: Oxford University Press, 1995.
37. Reynolds MR, Magnuson EA, Lei Y, et al. Health-related quality of life after transcatheter aortic valve replacement in inoperable patients with severe aortic stenosis. *Circulation* 2011;124:1964-72.
38. Bunte MC, Cohen DJ, Jaff MR, et al. Long-term clinical and quality of life outcomes after stenting of femoropopliteal artery stenosis: 3-year results from the STROLL study. *Catheter Cardiovasc Interv* 2018;92:106-14.
39. Kahn SR, Julian JA, Kearon C, et al. Quality of life after pharmacomechanical catheter-directed thrombolysis for proximal deep venous thrombosis. *J Vasc Surg Venous Lymphat Disord* 2020;8(1):8-23.e18.
40. Li W, Vedantham S, Jaffer FA, et al. Revisiting the open vein hypothesis to reduce the post-thrombotic syndrome: implications for multidisciplinary care and research: a scientific statement from the American Heart Association. *Circulation* 2025;151(23):e1051-e1071.

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