Utility of the 50% stenosis criterion for patients undergoing stenting for chronic iliofemoral venous obstruction

Arjun Jayaraj, MD, Thomas Powell, MS, *and* Seshadri Raju, MD, *Jackson, Miss*

ABSTRACT

Objective: The criterion for venous stenting in symptomatic chronic iliofemoral venous obstruction has been the arbitrary use of stenosis of ≥50%. In the present study, we evaluated the intravascular ultrasound (IVUS)-determined degree of stenosis in patients who had undergone stenting for quality of life (QOL)-impairing symptoms and assessed the utility of the 50% stenosis cutoff.

Methods: A retrospective review of contemporaneously entered electronic medical record data from 480 continuous patients (480 limbs) with initial iliofemoral stents placed (2014 to 2017) for symptomatic chronic iliofemoral venous obstruction impairing their QOL was performed. The IVUS-determined normal minimal luminal areas for the common femoral vein (125 mm), external iliac vein (150 mm), and common iliac vein (200 mm) were used to group limbs as having <50% (low-grade stenosis [LGS]) or ≥50% (high-grade stenosis [HGS]) stenosis. The variables compared included the visual analog scale (VAS) for pain score, venous clinical severity score (VCSS; range, 0-27), ulcer healing, supine foot venous pressures, QOL (20-item chronic venous disease QOL questionnaire), and stent patency. A composite chronic venous insufficiency score (CCVIS) incorporating the VAS score, VCSS, and CIVIQ-20 score for predicting improvement after stenting was evaluated.

Results: Of the 480 limbs, 283 and 197 were in the LGS and HGS groups, respectively. A preponderance of women, left laterality, and post-thrombotic syndrome were noted in both groups. At baseline, although no difference was found in the VAS for pain score between groups, the LGS group had a higher VCSS than did the HGS group ($P = .05$). The baseline median supine foot venous pressure was 15 and 14 mm Hg in the LGS and HGS groups, respectively ($P = .17$). At 24 months after stenting, the mean VCSS had improved from 6.3 to 4.4 ($P < .0001$) and from 5.7 to 3.7 ($P < .0001$) in the LGS and HGS groups, respectively, without significant differences between the two groups ($P = .07$). A greater prevalence of ulcers was found in the LGS group (18% vs 11%; $P = .04$), with no differences in healing ($P = .41$) or recurrence rates ($P = .36$). The QOL scores had improved in both groups (LGS, from 58 to 37 [$P < .0001$]; HGS, from 61 to 35 [$P < .0001$]), without differences between the two groups ($P > .3$). No significant differences in stent patency or reinterventions rates were found. A baseline CCVIS of ≥84.5, ≥86.9, or ≥105.3 was needed for a 30-, 40-, and 50-point improvement in most limbs after stenting.

Conclusions: The degree of IVUS-determined iliofemoral venous stenosis did not appear to affect the initial clinical presentation, CEAP (clinical, etiologic, anatomic, pathophysiologic) clinical class, supine foot venous pressure, clinical improvement, QOL improvement, stent patency, or reintervention rates after stenting. Patients presenting with QOL-impairing symptoms in whom conservative treatment has failed merit consideration of correction of their obstruction even if the degree of stenosis is <50%. The use of a CCVIS might be helpful but requires further study. (J Vasc Surg Venous Lymphat Disord 2021;9:1408-15.)

Keywords: Chronic iliofemoral venous obstruction; Iliac vein stenosis; May Thurner syndrome; Non thrombotic iliac vein lesion; Post thrombotic syndrome; Venous stenting

Stenting has replaced open surgery as the first line of treatment of symptomatic chronic iliofemoral venous obstruction (CIVO) for many years now.[1-8] With this change came the use of venography and then intravascular ultrasound (IVUS) for the diagnosis and treatment of CIVO. The current paradigm for the confirmation of the diagnosis and treatment of CIVO is through the use of IVUS. The correct diagnostic criteria that merits stenting in symptomatic patients remain to be determined. Arbitrarily, the use of 50% stenosis has been suggested, which was derived from the concept of critical stenosis in the arteries. However, it must be remembered that the venous side of circulation is very different from the arterial side, and such a

From The RANE Center for Venous and Lymphatic Diseases, St Dominic Hospital.

Author conflict of interest: none.

Presented at the Thirty-third Annual Meeting of the American Venous Forum, San Antonio, Tex, March 17-20, 2021.

Correspondence: Arjun Jayaraj, MD, The RANE Center for Venous and Lymphatic Diseases, 971 Lakeland Dr, Ste 401, Jackson, MS 39216 (e-mail: jayaraj.arjun2015@gmail.com).

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.2021.05.008

criterion is not helpful. It was in this setting that we explored the utility of the 50% stenosis criterion for the diagnosis and treatment of CIVO.

METHODS

Study design. We performed a single-center retrospective analysis of prospectively collected data during a 4-year period from 2014 to 2017, representing a period of exclusive use of a composite stent configuration. The institutional review board approved the study for the dissemination of de-identified patient data. The patients provided written informed consent for the procedure.

Setting. Our center is a tertiary center for the management of venous and lymphatic disorders.

Participants. Individuals presenting with symptomatic CIVO who had undergone IVUS interrogation and iliofemoral venous stenting formed the study cohort. Conservative therapy had failed in these patients, and they had symptoms impairing their quality of life (QOL). Those who had undergone stenting after thrombolysis for acute deep vein thrombosis were excluded, because it was not possible to accurately assess the chronic stenosis component in the presence of acute thrombus. Patients who had undergone recanalization for chronic total occlusion were also excluded.

Intervention and follow-up. The diagnostic workup included duplex ultrasound (DUS), lymphoscintigraphy for patients with leg swelling, and cross-sectional imaging (computed tomography venography or magnetic resonance venography according to surgeon preference). Confirmation of the diagnosis was through IVUS interrogation, which was pursued for those who had presented with disabling symptoms, including heaviness, tiredness, pain, swelling, hyperpigmentation, lipodermatosclerosis, and/or venous leg ulcers. The IVUS criteria used for the diagnosis of iliofemoral venous obstruction included the use of the normal minimal luminal areas in the common femoral vein (CFV; 125 mm^2), external iliac vein (EIV; 150 mm^2), and common iliac vein (CIV; 200 mm^2).[9] Measurement of these normal minimal luminal areas was obtained using a combination of methods, including the distribution curve of IVUS planimetry data, Poiseuille's equation, and Young's scaling rule, and represented the focus of a previous report.[9] A luminal area less than these cutoff points was considered abnormal and meriting stenting in symptomatic patients.

Access was obtained in the mid-thigh femoral vein or popliteal vein (dictated by inflow) under ultrasound guidance, and an 11F, 10-cm sheath was placed. Venography was subsequently performed unless contraindicated. IVUS interrogation (Visions PV 0.035 digital IVUS catheter; Philips, Amsterdam, Netherlands) was then performed, and the diagnosis confirmed using the luminal area criteria. Predilation was pursued before stenting usually using a 16- or 18-mm angioplasty balloon inflated to a pressure greater than the nominal pressure at which equilibration occurs. Stenting was then performed using a composite stent configuration of a Wallstent body (Boston Scientific, Marlborough Mass) and a Z stent top (Cook Medical, Bloomington, Ind). The stent sizes used typically ranged from 16 to 20 mm in diameter for the Wallstent and 25 to 30 mm for the Z stent.[10,11] The length of the stent varied, with the goal of covering all areas of disease and with adequate overlap (2-3 cm) between stents to prevent shelving. The amount of caval extension was ~1 to 2 mm for the Wallstent and ≤20 mm for the Z stent. Caudally, the stent was extended into an area of good inflow as determined by IVUS interrogation. Stenting was followed by dilation (usually with the same angioplasty balloon used for predilation), completion IVUS interrogation to ensure adequate luminal areas had been attained, and completion venography.

Antithrombotic therapy included the use of prophylactic enoxaparin (30-40 mg subcutaneously) and bivalirudin 75 mg preoperatively. After the procedure, therapeutic enoxaparin (1 mg/kg/dose subcutaneously every 12 hours) was continued until discharge (day after procedure). Subsequently, a combination of anticoagulation (a direct oral anticoagulant or warfarin), cilostazol (50 mg twice daily), and aspirin (81 mg once daily) was used as long as no contraindications existed for their use. The duration was typically for 6 months after stenting. Anticoagulation was continued long term for patients with thrombophilia and

ARTICLE HIGHLIGHTS

- **Type of Research:** A single-center retrospective analysis of prospectively collected data
- **Key Findings:** The degree of intravascular ultrasound-identified iliofemoral venous stenosis does not appear to have an effect on the initial clinical presentation, CEAP (clinical, etiologic, anatomic, pathophysiologic) clinical class, or supine foot venous pressure in patients presenting with quality of life (QOL)-impairing chronic iliofemoral venous obstruction. Additionally, after stenting, clinical improvement, QOL improvement, stent patency, and a requirement for reintervention also appeared to be independent of the initial degree of venous stenosis.
- **Take Home Message:** Patients presenting with symptoms impairing their QOL in whom conservative treatment has failed merit consideration of correction of their chronic iliofemoral venous obstruction even if the degree of stenosis is <50% on intravascular ultrasound interrogation.

those who developed stent-related complications. Aspirin at 81 mg once daily was typically continued lifelong.

After the intervention, patients received a pair each of compression wraps and graduated compression stockings (20-30 mm Hg) with the recommendation for regular use. The follow-up protocol included DUS 1 day, 2 and 4 weeks, and 3, 6, and 12 months after stenting. Clinic visits started 6 weeks after intervention and continued thereafter to coincide with the DUS visits. Subsequent visits were typically annually as long as the patients remained without evidence of clinical recurrence impairing QOL or resulting in stent malfunction. Details pertaining to the stent technique, stent sizing and perioperative management have been described in previous reports.[4,10,12-14]

Measurements. The IVUS-determined normal minimal luminal areas of the CFV (125 mm^2), EIV (150 mm^2), and CIV (200 mm^2) segments obtained before predilation were used to determine the presence of ≥50% stenosis. Limb with ≥50% stenosis in one or more of these venous segments were included in the high-grade stenosis (HGS) group. Limbs with <50% stenosis in all segments were included in the low-grade stenosis (LGS) group. The clinical parameters evaluated included the visual analog scale (VAS) for pain (score range, 0-10), venous clinical severity score (VCSS; range, 0-27 [30 minus 3 points for compression stockings]), the presence of venous leg ulcers, and the 20-item chronic venous disease QOL questionnaire (CIVIQ-20). For the CIVIQ-20 instrument, the maximum score of 100 indicates the worst possible QOL and a score of 0, the best possible QOL.[15,16] The physical, pain, social, and psychological domains were considered individually and a global score was generated. The last available response was used in the postoperative outcomes analysis. All the scores were appraised at every clinic follow-up visit. Finally, we decided to pool the VAS for pain score, VCSS, and CIVIQ-20 scores to formulate a composite chronic venous insufficiency score (CCVIS; range, 0-134) to help determine a baseline score that would be predictive of significant improvement. The CCVIS was computed using 0 to 10 points for the VAS, 0 to 24 points for the VCSS (30 minus 6 [removed for compression stockings and pain score]), and 0 to 100 for the CIVIQ-20, for a maximum score of 134. The three points for pain were removed from the VCSS to prevent the duplication of pain scores from the VCSS and VAS for pain. Considering previously reported data on the improvement in scores for patients after intervention for venous insufficiency, a logistic probability plot was constructed for a 30-, 40-, and 50-point improvement from baseline.[17-20]

Reintervention. If during follow-up, the patients had developed recurrence of initial symptoms, they underwent IVUS interrogation and correction of the etiology of stent malfunction. The etiologies included in-stent restenosis (ISR), stent compression (SC), a combination of ISR and SC, and stent occlusion.

Statistical analysis. Statistical analysis was performed using SPSS statistics, version 24 (IBM Corp, Armonk, NY). The HGS and LGS groups were compared at baseline and after stenting using unpaired and paired *t* tests. Kaplan-Meier analysis was used to assess stent patency after intervention. A logistic probability plot was constructed to assess the baseline CCVIS that would be the most predictive of a 30-, 40-, or 50-point improvement. *P* values ≤.05 were considered statistically significant.

RESULTS

Of the 480 patients (480 limbs) who had undergone stenting, 197 were in the HGS group and 283 were in the LGS group. The demographic data of the two groups are presented in Table. Regarding the CEAP (clinical, etiologic, anatomic, pathophysiologic) clinical class, in the HGS group, 3 patients (2%) were C0, none were C1, 2 (1%) were C2, 64 (32%) were C3, 107 (54%) were C4, 4 (2%) were C5, and 17 (8.6%) were C6. In the LGS group, no patient was classified as C0, C1, or C2, 74 patients (26.2%) were C3, 159 (56.4%) were C4, 17 (6%) were C5, and 31 (11%) were C6. Except for CEAP clinical C4, which had a greater prevalence in the LGS ($P = .04$), no significant differences in the distribution of the CEAP clinical classes between the two groups were found. Patients with CEAP clinical C0 and C2 underwent intervention secondary to disabling venous claudication (ie, leg pain or tightness that developed with ambulation or exercise). The median follow-up period for the study was 27 months. The prevalence of deep venous reflux in the entire cohort was ∼2.5%, with a greater incidence in the LGS group (∼2%). The rate of interventions (single vessel endovenous laser ablation) for superficial venous reflux was ∼8% for the entire cohort, with an equal distribution between the two groups.

Effect of stenosis degree on initial clinical presentation. At baseline, no difference was found in the VAS for pain score (HGS, 4.9; vs LGS, 4.3; $P = .09$), between the two groups. However, the LGS group had a higher VCSS than the HGS group (HGS, 5.9; vs LGS, 6.5), with a statistically significant difference ($P = .05$). No statistically significant difference was found in the foot venous pressure between the two groups (HGS, 14 mm Hg; LGS, 15 mm Hg; $P = .17$). Although 21 limbs (11%) had had ulcers in the HGS group, 51 limbs (18%) had had ulcers in the LGS group ($P = .04$). Comparisons of the CIVIQ-20 score at baseline between the two groups revealed a median score of 61.3 in the HGS group and a corresponding score of 58.1 in the LGS group without a significant difference between the two groups ($P = .39$). The Pearson correlation between the VCSS and the

Table. Comparison of demographic parameters between the two groups

Variable	Stenosis ≥50% (n = 197)	Stenosis <50% (n = 283)	*P* value
Age, years	57.5 ± 15	59.4 ± 14	.1462
Female sex	147 (75)	181 (64)	**.0108**
BMI, kg/m^2	34.9 ± 9	37.9 ± 9	**.0005**
Left side	139 (71)	156 (55)	**.0004**
NIVL	38 (19)	63 (22)	.4259
PTS	124 (63)	183 (65)	.6534
NIVL + PTS	35 (18)	37 (13)	.1322

BMI, Body mass index; *NIVL,* nonthrombotic iliac vein lesion; *PTS,* post-thrombotic syndrome.
Data presented as mean ± standard deviation or number (%).
Boldface *P* values represent statistical significance.

degree of stenosis ($r = -0.12$; $P = .009$) and the Spearman correlation between the CEAP clinical class and the degree of stenosis ($r = -0.14$; $P = .002$) are considered in Figs 1 and 2, respectively.

Effect of stenting on clinical characteristics. After stenting, improvement occurred in the clinical parameters in both groups. At 12 months, in the HGS group the VCSS (n = 103) had improved from 6 to 4.2 ($P < .0001$) and the VAS for pain score (n = 72) had improved from 5 to 2.7 ($P < .0001$). At 12 months, in the LGS group, the VCSS (n = 146) had improved from 6.4 to 4.1 ($P < .0001$), and the VAS for pain score (n = 114) had improved from 4.1 to 2.4 ($P < .0001$).

At 24 months, in the HGS group, the VCSS (n = 81) had improved from 5.7 to 3.7 ($P < .0001$) and the VAS for pain score (n = 57) had improved from 4.9 to 2.8 ($P < .0001$). At 24 months, in the LGS group, the VCSS (n = 96) had improved from 6.3 to 4.4 ($P < .0001$) and the VAS for pain score (n = 77) had improved from 4.2 to 2.9 ($P < .0001$). No statistically significant difference was found between the two groups in the VCSS or VAS for pain score at either 12 or 24 months.

Ulcer healing was noted in 15 limbs (71%) in the HGS group and 41 limbs (80%) in the LGS group ($P = .41$). During the follow-up period, ulcer recurrence was not noted in any of the limbs in the HGS group, although recurrence had developed in two limbs (4%) in the LGS group ($P = .36$). The median CIVIQ-20 score had improved from 61.3 to 35 ($P < .0001$) in the HGS group after stenting and had improved from 58.1 to 36.9 ($P < .0001$) in the LGS group without a

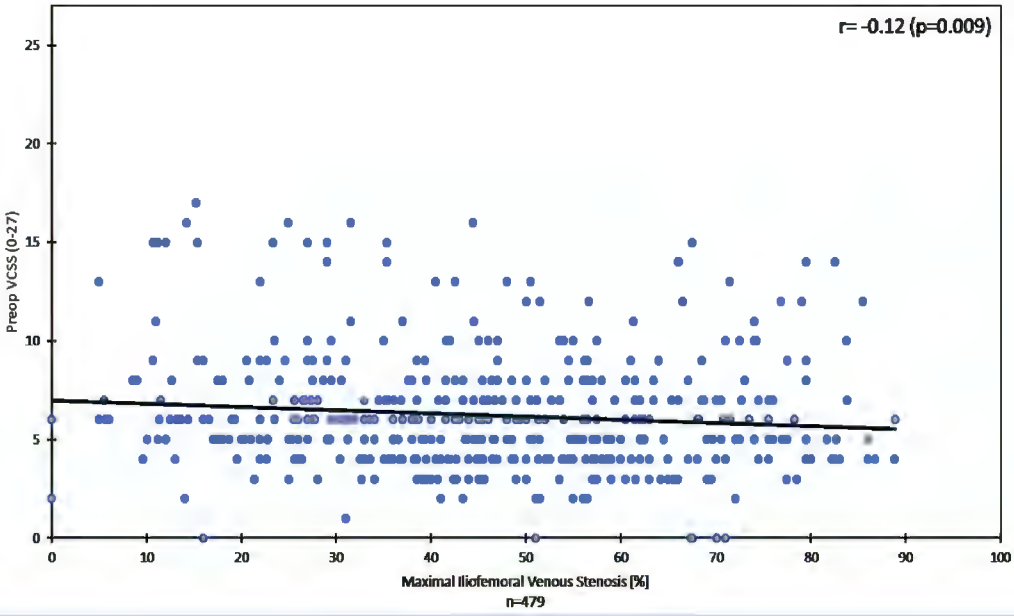

Fig 1. Pearson correlation between percentage of iliofemoral venous stenosis and venous clinical severity score (VCSS).

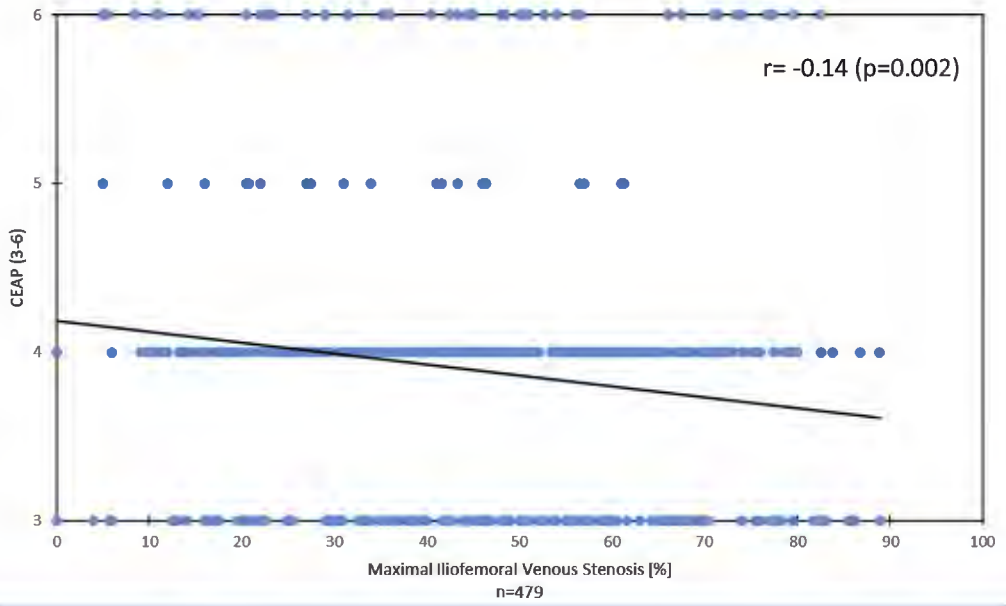

Fig 2. Spearman correlation between percentage of iliofemoral venous stenosis and CEAP (clinical, etiologic, anatomic, pathophysiologic) clinical class.

statistically significant difference between the two groups ($P = .64$).

Logistic probability plot. The CCVIS used for the logistic probability plot was a combination of the VAS for pain score (range, 0-10), the VCSS (range, 0-24), and CIVIQ-20 score (range, 0-100), for a maximum possible CCVIS of 134. The plot in Fig 3 depicts the baseline CCVIS that would predict for a 30-, 40-, and 50-point improvement in most patients after stenting. For a 30-point improvement, the baseline CCVIS would have to be ≥84.5 points, for a 40-point improvement, it would need to be ≥86.9, and for a 50-point improvement, the baseline CCVIS would have to be ≥105.3.

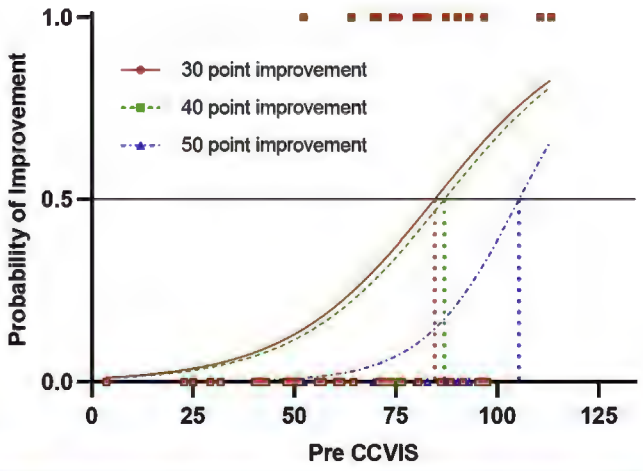

Fig 3. Logistic probability plot for composite chronic venous insufficiency score (CCVIS).

Stent-related outcomes. Primary patency after stenting in the HGS group at 60 months was 73% and in the LGS group was 70% ($P = .67$). Primary assisted patency at 60 months was 100% in both groups ($P = .99$). Secondary patency at 48 months in both groups was also 100% ($P = .99$). Stent patency is shown in Fig 4. A total of 42 limbs (21%) had required reintervention in the HGS group (ISR, 19 [9.5%]; ISR + SC, 17 [8.5%]; stent occlusion, 6 [3%]) and 50 limbs (18%) in the LGS group (ISR, 23 [8%]; SC, 1 [<1%]; ISR + SC, 25 [9%]; stent occlusion, 1 [<1%]), without a significant difference between the two groups ($P = .41$).

Anatomic characteristics. Of the 197 limbs with HGS, 171 CIV, 56 EIV, and 16 CFV segments had had stenosis of ≥50%. The segment with the maximal stenosis in the HGS group was the CIV in 164 limbs (83%), the EIV in 27 limbs (14%), and the CFV in 6 limbs (3%). In addition, 155 limbs (79%) had had >50% stenosis in one of three segments, 38 limbs (19%) in two of three segments, and 4 (2%) in all three segments. Of the 283 limbs in the LGS group, maximal stenosis was noted in the CIV in 163 (58%), EIV in 79 (28%), and CFV in 41 (14%). The CIV segment was the site of maximal stenosis in both groups, followed by the EIV segment and CFV segment.

DISCUSSION

Over the years, the 50% stenosis concept as a cutoff for treatment of patients presenting with CIVO has gained favor. This cutoff has been used often in studies evaluating the use of venous stents. The basis for this cutoff is arbitrary and appears to have been extrapolated from the arterial literature. However, a fundamental

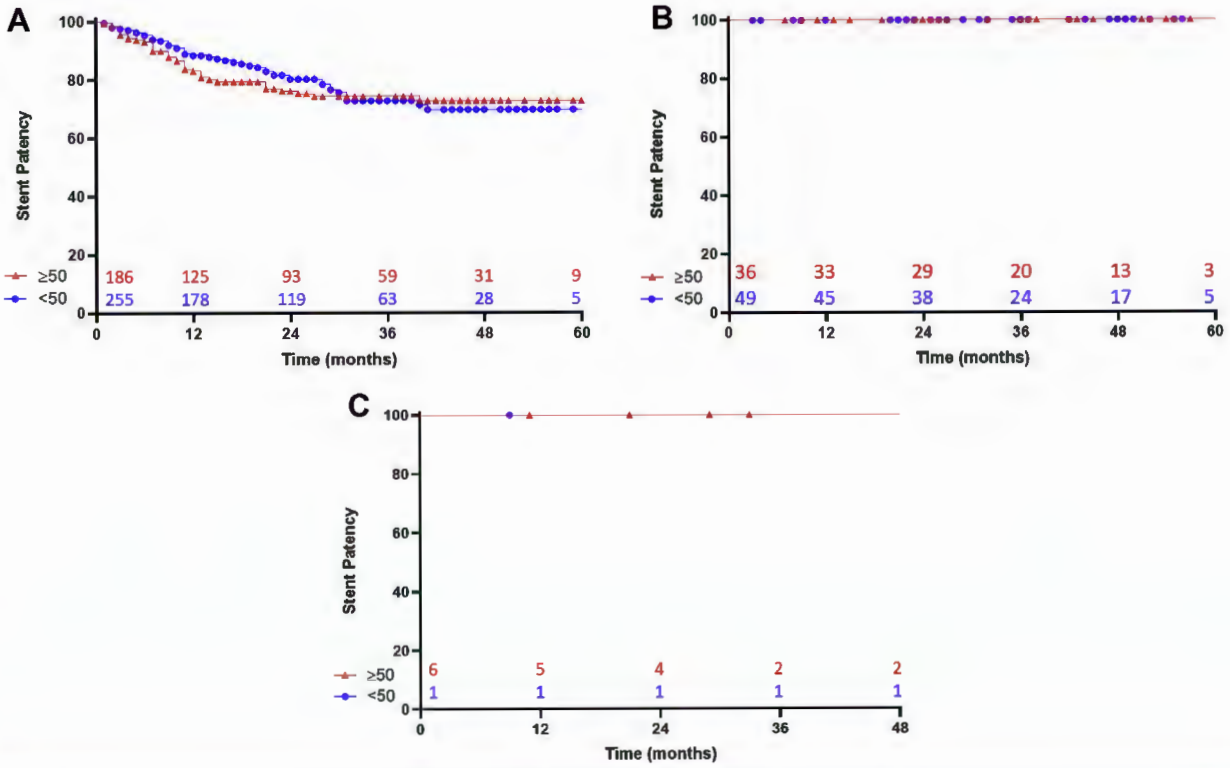

Fig 4. A, Plot demonstrating primary stent patency between high-grade stenosis (HGS) and low-grade stenosis (LGS) groups (standard error of the mean, <10%). **B,** Plot demonstrating primary assisted patency between HGS and LGS groups (standard error of the mean, <10%). **C,** Plot demonstrating secondary stent patency between HGS and LGS groups (standard error of the mean, <10%).

difference exists in the role of correction of stenotic lesions in the arterial tree vs the venous system. Although for the arterial system, the goal of stenting or bypass is to restore perfusion, in the venous system, the goal of correction of an obstructive lesion is to alleviate venous hypertension.

Physiological basis for correction of CIVO. Poiseuille's equation gives us the relationship between flow, pressure gradient, and resistance as follows:

$$\text{Flow (F)} = \frac{\text{Pressure gradient } (\Delta P)}{\text{Resistance (R)}}$$

$$F = \frac{\Delta P \pi r^4}{8 L \eta}$$

where L is the length of the vein, η is the viscosity of blood, and r is the radius of the vein.

Because flow is related to r^4, correcting a lesion only when ≥50% stenosis is present would mean that the lower limb is able to tolerate a 16 times reduction in flow without the development of venous hypertension. However, does not consider the three to five times increase in flow that occurs with exercise. From the physiological standpoint, venous hypertension would not develop in such a scenario only if significant collateralization was able to compensate for the reduced caliber of the iliofemoral system. Thus, for a 16-mm CIV stenotic to 8 mm it would require 128 collateral vessels, each 4 mm in diameter, to compensate by providing alternate channels of flow, given the relationship of flow to the fourth power of radius. Such compensation seldom occurs and represents a fatal flaw in the 50% stenosis concept from a physiological standpoint.

CIVO degree does not affect initial clinical presentation. Although the LGS group had had a significantly higher baseline VCSS compared with the HGS group, no such difference was noted when the VAS for pain scores were compared. The LGS group had a greater proportion of ulcers (18% vs 11%; $P = .04$), indicating that a greater degree of stenosis does not necessarily result in a more advanced form of chronic venous insufficiency. This was also supported by the statistically significant small negative Pearson and Spearman correlation between the VCSS and CEAP clinical class and the degree of iliofemoral venous stenosis, respectively (Figs 1 and 2). Five patients in the HGS group had had CEAP C0 and C2. The clinical manifestation in these patients was disabling venous claudication (ie, leg pain or tightness that develops with ambulation and exercise). The pathology of

venous claudication is secondary to the high fixed resistance to venous outflow with walking and exercise as a result of the obstruction.[21] Although these individuals might have collateral channels, the latter will also offer similar resistance, with the result that the venous return out of the limb is unable to keep up with the increased arterial inflow that occurs with such activity. Edema will be present but is intramuscular in nature, and, often, these patients will have chronic intramuscular edema as evidenced by large calves and/or thighs.[21,22] These patients will typically not have skin or soft tissue edema that would indicate the C3 category. They might or might not have reticular or varicose veins, which would indicate C1 or C2. Thus, the CEAP class for some patients will be C0. Other studies have also described venous claudication as a presenting manifestation of CIVO and subsequent benefit from venous stenting.[23,24] Foot venous pressure, an often-used quantitative surrogate for venous hypertension, did not vary between the two groups ($P = .17$). Regarding QOL, no significant difference was found between the baseline CIVIQ-20 scores between the two groups (HGS, 61.3; LGS, 58.1; $P = .39$). Thus, the degree of baseline iliofemoral venous stenosis does not appear to affect the initial clinical presentation or QOL vis-à-vis a greater degree of stenosis resulting in a worse clinical presentation.

CIVO degree does not affect clinical or stent outcomes after intervention. The results of the present study revealed improvement across the board at 12 and 24 months after stenting in the VCSS, VAS for pain score, and CIVIQ-20 score without significant differences between the LGS and HGS groups. These findings support the observation that the degree of iliofemoral venous stenosis does not determine the clinical outcomes after stenting. This also applied to the healing of ulcers, with a 71% ulcer healing rate for the HGS group and an 80% healing rate for the LGS group ($P = .41$). A greater stenosis degree also did not result in an increased rate of ulcer recurrence. Another finding was that a greater degree of stenosis did not result in worse stent outcomes. No statistically significant difference was found in primary, primary assisted, and secondary patency after stenting between the two groups. Additionally, no significant differences were found in the reintervention rates between the HGS and LGS groups. A similar spread was found for both groups regarding the reason for reintervention, with ISR (with or without SC) the most common reason, followed by stent occlusion and SC alone.

Effect of reflux. Overall, the prevalence of both superficial and deep venous reflux was similar in the two groups. Neither group had required intervention for deep venous reflux after correction of the obstruction. This is in keeping with the previous finding that deep venous reflux seldom requires intervention after correction of the obstruction.[25] Both groups had required a similar number of laser ablations for superficial venous reflux. Concomitant correction of superficial venous reflux is important for patients with CEAP C4 to C6 because venous drainage from the skin and soft tissue is primarily through the superficial system. The importance of a comprehensive venous evaluation before intervention cannot be overemphasized. In our practice, the preoperative workup includes DUS to evaluate the superficial and deep venous systems (including the iliac venous segments and infrarenal inferior vena cava), air plethysmography, lymphoscintigraphy for patients with swelling, and noninvasive cross-sectional imaging (computed tomography and/or magnetic resonance imaging).

Logistic probability plot and intervention for patients presenting with CIVO. Given that the 50% stenosis criterion is not helpful in determining which patients for whom correction of iliofemoral venous stenosis would be beneficial, a novel composite score was postulated and evaluated to provide information on this aspect. Our CCVIS has a maximum score of 134 and uses a combination of the VAS for pain score (range, 0-10), VCSS (range, 0-24), and CIVIQ-20 (range, 0-100). The CIVIQ score was used because it represents the most relevant metric affecting the patient—QOL. The rationale for giving the CIVIQ-20 score such weight was because the treatment of CIVO is to help restore patients' QOL, not limb or leg preservation. One of the shortcomings of the VCSS is that it is skewed toward more advanced disease, especially ulceration. However, the effects on QOL can be just as bad or worse for a police officer, firefighter, postal worker, or anyone constantly on their feet with severe edema and/or pain as for someone with more sedentary employment with a venous leg ulcer. This is an often missed aspect when considering intervention for venous disease and was our rationale for including the 10-point VAS for pain score instead of the 3-point pain score of the VCSS as a part of the CCVIS. Additionally, too much emphasis has been placed over the years on determining the percentage of stenosis that would serve as a cutoff for determining correction of CIVO. The 50% concept, as noted previously, is an extension of the cutoff concept used to determine when to perform an intervention for arterial claudication or critical limb ischemia. The purpose of the correction of venous obstruction, however, is fundamentally different from the purpose of stenting in the arterial system. A symptomatic patient with QOL impairment merits correction of their CIVO even if the degree of obstruction is 20% because that degree of stenosis is enough to cause venous hypertension. In contrast, no role exists for stenting an 80% stenosis in an asymptomatic patient or even a symptomatic patient if their symptoms are not impairing their QOL or are responding to conservative measures. Thus, we need

to move away from the "stenting for the degree of stenosis concept" to stenting for symptoms impairing the patient's QOL, because the goal of treatment of patients with CIVO is to improve their QOL and not to save their limb and/or life. The CCVIS is an endeavor in this direction. In the present cohort, the median CCVIS was 70, which had improved to 42.25, indicating a 27.75-point improvement. From previous work, a median improvement in the CCVIS of ~29 was noted after the use of a composite stent configuration for CIVO.[10]

Study limitations. The inherent retrospective nature of the present study was a shortcoming. Additionally, the loss of patients to follow-up after stenting was an issue. No good methods exist to counter these limitations, which likely affected the results of the present study. We also acknowledge that the CCVIS represents an initial attempt to determine a metric that would be able to predict clinical and QOL improvement after stenting. More work is required in this regard, especially for validation of the score.

CONCLUSIONS

The degree of IVUS-determined iliofemoral venous stenosis does not appear to affect the initial clinical presentation, CEAP clinical class, supine foot venous pressure, clinical improvement, QOL improvement, stent patency, or reintervention rates after stenting. Patients presenting with QOL-impairing symptoms of CIVO for whom conservative therapy has failed merit consideration of correction of their obstruction even if the degree of stenosis is <50%. The use of our CCVIS could be helpful in this regard but requires further study.

AUTHOR CONTRIBUTIONS

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

REFERENCES

1. Knipp BS, Ferguson E, Williams DM, Dasika NJ, Cwikiel W, Henke PK, et al. Factors associated with outcome after interventional treatment of symptomatic iliac vein compression syndrome. J Vasc Surg 2007;46:743-9.
2. Hartung O, Loundou AD, Barthelemy P, Arnoux D, Boufi M, Alimi YS. Endovascular management of chronic disabling ilio-caval obstructive lesions: long-term results. Eur J Vasc Endovasc Surg 2009;38:118-24.
3. Ye K, Lu X, Li W, Huang Y, Huang X, Lu M, et al. Long-term outcomes of stent placement for symptomatic nonthrombotic iliac vein compression lesions in chronic venous disease. J Vasc Interv Radiol 2012;23:497-502.
4. Neglen P, Hollis KC, Olivier J, Raju S. Stenting of the venous outflow in chronic venous disease: long-term stent-related outcome, clinical, and hemodynamic result. J Vasc Surg 2007;46:979-90.
5. Gutzeit A, Zollikofer CL, Dettling-Pizzolato M, Graf N, Largiader J, Binkert CA. Endovascular stent treatment for symptomatic benign iliofemoral venous occlusive disease: long-term results 1987-2009. Cardiovasc Intervent Radiol 2011;34:542-9.
6. Alhalbouni S, Hingorani A, Shiferson A, Gopal K, Jung D, Novak D, et al. Iliac-femoral venous stenting for lower extremity venous stasis symptoms. Ann Vasc Surg 2012;26:185-9.
7. Qiu P, Zha B, Xu A, Wang W, Zhan Y, Zhu X, et al. Systematic review and meta-analysis of iliofemoral stenting for post-thrombotic syndrome. Eur J Vasc Endovasc Surg 2019;57:407-16.
8. Seager MJ, Busuttil A, Dharmarajah B, Davies AH. Editor's choice — a systematic review of endovenous stenting in chronic venous disease secondary to iliac vein obstruction. Eur J Vasc Endovasc Surg 2016;51:100-20.
9. Raju S, Buck WJ, Crim W, Jayaraj A. Optimal sizing of iliac vein stents. Phlebology 2018;33:451-7.
10. Jayaraj A, Noel C, Kuykendall R, Raju S. Long-term outcomes following use of a composite Wallstent-Z stent approach to iliofemoral venous stenting. J Vasc Surg Venous Lymphat Disord 2021;9:393-400.
11. Jayaraj A, Raju S. Three-dimensional computed tomography venogram enables accurate diagnosis and treatment of patients presenting with symptomatic chronic iliofemoral venous obstruction. J Vasc Surg Venous Lymphat Disord 2021;9:73-80.
12. Jayaraj A, Buck W, Knight A, Johns B, Raju S. Impact of degree of stenosis in May-Thurner syndrome on iliac vein stenting. J Vasc Surg Venous Lymphat Disord 2019;7:195-202.
13. Jayaraj A, Crim W, Knight A, Raju S. Characteristics and outcomes of stent occlusion after iliocaval stenting. J Vasc Surg Venous Lymphat Disord 2019;7:56-64.
14. Jayaraj A, Noel C, Raju S. Contralateral limb improvement after unilateral iliac vein stenting argues against simultaneous bilateral stenting. J Vasc Surg Venous Lymphat Disord 2020;8:565-71.
15. Launois R, Rebpi-Marty J, Henry B. Construction and validation of a quality of life questionnaire in chronic lower limb venous insufficiency (CIVIQ). Qual Life Res 1996;5:539-54.
16. Launois R, Mansilha A, Jantet G. International psychometric validation of the chronic venous disease quality of life questionnaire (CIVIQ-20). Eur J Vasc Endovasc Surg 2010;40:783-9.
17. Razavi MK, Black S, Gagne P, Chiacchierini R, Nicolini P, Marston W, et al. Pivotal study of endovenous stent placement for symptomatic iliofemoral venous obstruction. Circ Cardiovasc Interv 2019;12:e008268.
18. Gagne PJ, Gasparis A, Black S, Thorpe P, Passman M, Vedantham S, et al. Analysis of threshold stenosis by multiplanar venogram and intravascular ultrasound examination for predicting clinical improvement after iliofemoral vein stenting in the VIDIO trial. J Vasc Surg Venous Lymphat Disord 2018;6:48-56.
19. Falcoz MT, Falvo N, Aho-Glele S, Demaistre E, Galland C, Favelier S, et al. Endovascular stent placement for chronic post-thrombotic symptomatic ilio-femoral venous obstructive lesions: a single-center study of safety, efficacy and quality-of-life improvement. Quant Imaging Med Surg 2016;6:342-52.
20. Guillen K, Falvo N, Nakai M, Chevallier O, Aho-Glele S, Galland C, et al. Endovascular stenting for chronic femoro-iliac venous obstructive disease: clinical efficacy and short-term outcomes. Diagn Interv Imaging 2020;101:15-23.
21. Killewich LA, Martin R, Cramer M, Beach KW, Strandness DE Jr. Pathophysiology of venous claudication. J Vasc Surg 1984;1:507-11.
22. Qvarfordt P, Eklof B, Ohlin P, Plate G, Saltin B. Intramuscular pressure, blood flow, and skeletal muscle metabolism in patients with venous claudication. Surgery 1984;95:191-5.
23. Broholm R, Baekgaard N, Just SR, Jorgensen M. [Endovascular treatment of chronic iliac vein obstruction in patients with venous claudication]. Ugeskr Laeger 2007;169:1564-8.
24. Delis KT, Bjarnason H, Wennberg PW, Rooke TW, Gloviczki 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.
25. Raju S, Darcey R, Neglen P. Unexpected major role for venous stenting in deep reflux disease. J Vasc Surg 2010;51:401-8.

Submitted Oct 12, 2020; accepted May 20, 2021.