Comparative study between the use of intravascular ultrasound versus conventional venography in management of iliofemoral chronic venous insufficiency

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Objective
The current study was carried out to reveal the added value of intravascular ultrasound (IVUS) in the diagnosis, clinical decision, and subsequent outcomes of the treatment of iliofemoral chronic venous insufficiency, relative to contrast multiplanar venography.
Patients and methods
This is a prospective randomized study encompassing 40 patients with symptomatic chronic venous insufficiency. Patients were randomly stratified into two groups; 20 patients were randomized into exclusively having multiplanar venography, and the other group would have IVUS in addition to completion venography to guide the intervention.
Results
Both the duration of the procedure and amount of contrast injected were significantly higher in the venography group (P=0.014 and P<0.0001, respectively). Postoperative creatinine was significantly less in the IVUS group (P<0.0001), and the mean increase in serum creatinine was significantly higher in the venography group (P<0.0001). Target lesion revascularization was significantly higher in the venography group (P=0.002).
IVUS detected a mean of 2.75 significant lesions compared with a mean of 1.6 lesions detected through venography (P<0.001) and was more able to detect stenoses and occlusions than computed tomography venography during follow-up, with a P value of 0.018. IVUS group showed a statistically significant higher primary assisted patency rate compared with venography, with a P value of 0.017.
Conclusion
IVUS is one of the most effective tools in the armamentarium of a vascular surgeon and interventionalist, especially when dealing with venous disorders. Our study suggests that as an imaging modality, it provides more sensitive and accurate details of the lesion, aids in setting a more appropriate plan, guides the surgeon through a more precise sizing and deployment of the necessary stents, and finally, provides a better follow-up tool to detect and guide subsequent interventions, resulting in higher primary assisted and secondary patency rates.

Keywords:
intravascular ultrasound, postthrombotic syndrome, venoplasty

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Introduction

Deep vein thrombosis (DVT) is a major health care risk causing fatal short-term complications as well as grave long-term effects. It affects approximately two patients per 1000 population, and results in postthrombotic syndrome (PTS) in 0–50% of patients even if patients received the optimal anticoagulant therapy [1,2].

PTS manifests as a spectrum of symptoms and signs of chronic venous insufficiency (CVI) that can impose significant morbidity and have a negative effect on quality of life. Chronic venous hypertension caused by a combination of residual venous obstruction and valvular reflux is believed to play a major role in the pathophysiology of PTS [2]. Patients with iliofemoral DVT managed conservatively with anticoagulation therapy and compression stockings have a high risk of PTS. Less than half of these patients regain iliofemoral patency, which is a main predictor for the development of PTS, and subsequently signs and symptoms of CVI [3]. Management of CVI is difficult and the key for successful treatment is proper diagnosis, which mainly depends on proper imaging.

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Venography has been widely used to diagnose venous obstruction. Evidence of obstruction using venography includes abundance of collaterals, pancaking, parrot beak appearance, and venous dilatation proximal to obstruction. However, degree of sensitivity of venography has been reported to vary greatly according to the site of obstruction or stenosis [4].

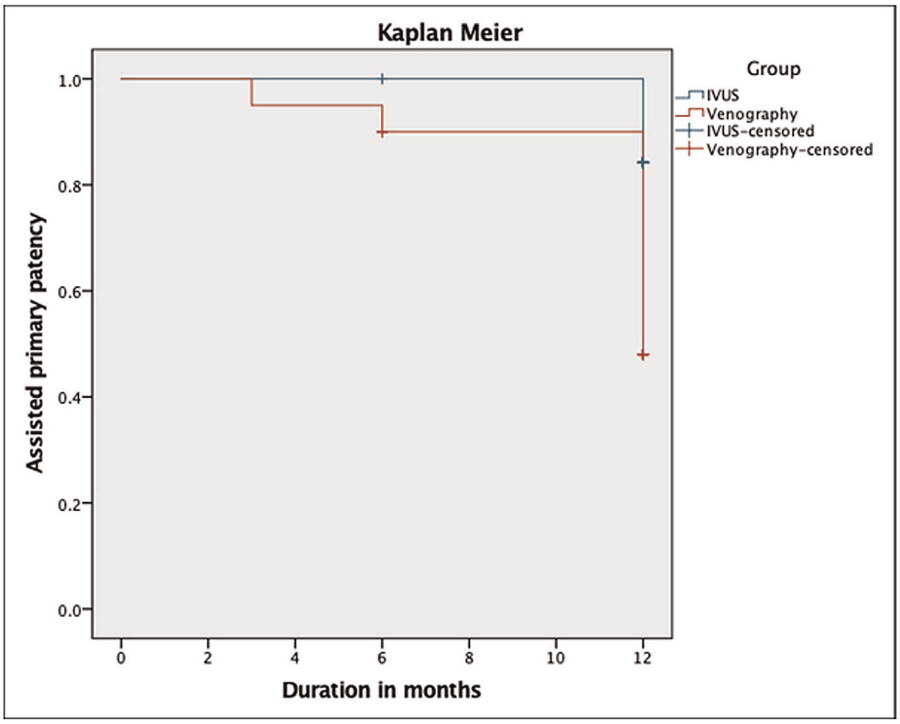
Intravascular ultrasound (IVUS) has been emerging as a more informative diagnostic tool when it comes to detecting areas and degrees of stenosis compared with multiplanar venography owing to its ability to identify and measure the cross-sectional area and degree of stenosis in the often irregular and noncircular venous lumen [5].

Patients and methods

This is a prospective randomized study encompassing 40 patients with symptomatic CVI starting June 2016 till June 2020 in Ain Shams University Hospitals and Egypt Air Hospital. Patients were randomly stratified through a computer-generated randomization pattern into two groups: 20 patients were randomized into exclusively having multiplanar venography to guide venoplasty, where the three planes were anteroposterior, 30 degree left anterior oblique, and 30 degree right anterior oblique projections (venography group), and the other group would have IVUS in addition to completion venography to guide the intervention (IVUS group) (Fig. 1). All participating patients had to sign an informed consent, and ethical committee approval from Ain Shams University ethical committee was obtained before initiation of the study. Patients who fulfilled the inclusion criteria (Table 1) had venoplasty performed for CVI, with recording of number and types of lesions, need for stent placement, number of stent deployed, operation time, amount of contrast, and technical success using the different imaging modalities. In all patients undergoing stenting of the iliac vein owing to compression, the proximal stent was placed protruding in the IVC [6] (Tables 2–4).

Stenosis was considered significant if more than 50% than the luminal diameter in venography or surface area in IVUS. In all patients who underwent stenting for PTS, the whole iliac venous axis was covered by stents from the IVC crossing the inguinal ligament preserving the profunda vein, and when multiple stents were used, an overlap of at least 1 cm was maintained between each stent and the other [7]. Stent sizing was done through measurement of the dimeter of the reference vessel (most proximal unaffected vein segment of normal diameter) using preoperative computed tomography (CT) venography in

Figure 1



Kaplan–Meier curve showing assisted primary patency.

Table 1 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
1. Patient must be above 18 years of age	1. Refusal to sign the consent and participate in the study
2. Willing to participate in the study	2. Active malignancy
3. Previous history of at least a single documented iliofemoral DVT	3. Renal impairment with persistently elevated serum creatinine level
4. Class 4, 5, or 6 in CEAP classification [11]	4. Acute deep venous thrombosis
	5. Known allergy to iodinated contrast
	6. Pregnancy either during recruitment or presence of an intent for pregnancy during the study duration
	7. Known thrombophilia
	8. Previous venous surgery or venoplasty with or without stenting

DVT, deep vein thrombosis.

Table 2 Association of preoperative Duplex study between intravascular ultrasound and venography groups

	Group		
	IVUS	Venography	*P* value
Preoperative duplex lesion type			
Stenosis	9	5	0.4**
	64.3%	35.7%	
Occlusion	10	14	
	41.7%	58.3%	
NAD	1	1	
	50.0%	50.0%	
Common iliac vein	2	0	
	100.0%	0.0%	
External iliac vein	3	2	
	60.0%	40.0%	
Common femoral vein	5	5	
	50.0%	50.0%	
Preoperative duplex lesion site			
Common and external iliac veins	0	5	0.115*
	0.0%	100.0%	
Common iliac, external iliac, and common femoral vein	2	2	
	50.0%	50.0%	
External iliac vein and common femoral vein	7	5	
	58.3%	41.7%	
NAD	1	1	
	50.0%	50.0%	

IVUS, intravascular ultrasound. **P*-value calculated using Chi square test. ***P*-value calculated using Liklihood ratio.

venography group, and reference vessel surface area using IVUS in IVUS group. Postoperatively, patients were kept on antiplatelets and class II compression stockings and assessed serially using the venous clinical severity scoring (VCSS) in addition to venous duplex on 3 monthly basis. For those who presented with restenosis, only CT venography was done in the venography group, and both CT venography and IVUS were done in the IVUS group. Primary end point was comparing number of lesions detected through IVUS with those detected through venography in the IVUS group [8].

Secondary end points included technical success and reintervention rates between the IVUS and venography groups.

Results

In total, 40 patients were enrolled in this study. There were no mortalities among the patients, and the follow-up duration was 18 months. Mean age was 47 years (SD 8), 29 (72.5%) patients were males, 31 (77.5%) were diabetics, mean number of days since last DVT was 236 days (SD 54), and mean VCSS was 19 initially, and 14, 9, 7, and 5 at 1, 3, 6, and 12 months, respectively. Preoperative duplex showed stenosis in 14 (35%) lesions, occlusion in 24 (60%) lesions and no significant stenosis or occlusion in two (5%) lesions. Lesions were most situated in the external iliac and common femoral vein (30%), then isolated common femoral vein (25%), then equally in common and external iliac veins and external iliac vein alone

Table 3 Association of preoperative medications and presenting symptoms between intravascular ultrasound and venography groups

	Group		
	IVUS	Venography	*P* value
Venous claudication			
Yes	20	20	–
	50.0%	50.0%	
	20	20	
	50.0%	50.0%	
Pigmentation			
No	11	10	0.75*
	52.4%	47.6%	
Yes	9	10	
	47.4%	52.6%	
Venous ulcer			
No	17	16	0.5**
	51.5%	48.5%	
Yes	3	4	
	42.9%	57.1%	
Associated peripheral ischemia			
No	19	18	0.5**
	51.4%	48.6%	
Yes	1	2	
	33.3%	66.7%	
Pain			
Daily	8	8	1
	50.0%	50.0%	
Daily with medication	12	12	
	50.0%	50.0%	
Varicose veins			
Absent	4	3	0.76**
	57.1%	42.9%	
Few	12	10	
	54.5%	45.5%	
Multiple	3	5	
	37.5%	62.5%	
Extensive	1	2	
	33.3%	66.7%	
Venous edema			
Evening only	0	1	0.35**
	0.0%	100.0%	
Afternoon	5	7	
	41.7%	58.3%	
Morning	15	12	
	55.6%	44.4%	
Pigmentation			
None	11	9	0.83**
	55.0%	45.0%	
Limited and old	1	1	
	50.0%	50.0%	
Diffuse and more recent	6	6	
	50.0%	50.0%	
Wide and recent	2	4	
	33.3%	66.7%	
Inflammation			
None	8	7	0.29**
	53.3%	46.7%	
Mild cellulitis	4	8	
	33.3%	66.7%	

(*Continued*)

Table3 ***(Continued)***

	Group		
	IVUS	Venography	*P* value
Moderate cellulitis	6	2	
	75.0%	25.0%	
Severe cellulitis	2	3	
	40.0%	60.0%	
Induration			
None	13	10	0.53**
	56.5%	43.5%	
Focal <5 cm	4	3	
	57.1%	42.9%	
<1/3 gaiter	2	5	
	28.6%	71.4%	
>1/3 gaiter	1	2	
	33.3%	66.7%	
Active ulcers			
None	17	16	0.7**
	51.5%	48.5%	
1	2	2	
	50.0%	50.0%	
2	0	1	
	0.0%	100.0%	
>2	1	1	
	50.0%	50.0%	
Ulcer duration			
None	17	16	0.49**
	51.5%	48.5%	
<3 months	0	1	
	0.0%	100.0%	
3–12 months	3	3	
	50.0%	50.0%	
Ulcer size			
None	17	16	1.4**
	51.5%	48.5%	
2–6 cm	3	3	
	50.0%	50.0%	
>6 cm	0	1	
	0.0%	100.0%	
Compression therapy			
Intermittent	5	3	0.72**
	62.5%	37.5%	
Most days	8	9	
	47.1%	52.9%	
Fully compliant	7	8	
	46.7%	53.3%	
Preoperative anticoagulation			
No	15	16	0.7**
	48.4%	51.6%	
Yes	5	4	
	55.6%	44.4%	

IVUS, intravascular ultrasound. **P*-value calculated using Chi square test. ***P*-value calculated using Liklihood ratio.

(12.5% each), and least frequently, the whole iliofemoral segment (10%) (Tables 5–8).

There were no statistically significant differences between baseline clinical data and laboratory investigations in the two groups, with the exception of a statistically significant higher level of glycated hemoglobin in the venography group (P=0.03). Both the duration of the procedure and amount of contrast injected were significantly higher in the

Table 4 Association of operative data between intravascular ultrasound and venography groups

	Group		
	IVUS	Venography	*P* value
Guidewire			
Standard	9	8	0.8**
	52.9%	47.1%	
Standard+superstiff amplatz	10	10	
	50.0%	50.0%	
Standard+superstiff amplatz+0.018 stiff	1	2	
	33.3%	66.7%	
Balloon diameter			
12	0	1	0.65**
	0.0%	100.0%	
14	8	7	
	53.3%	46.7%	
16	7	8	
	46.7%	53.3%	
18	5	4	
	55.6%	44.4%	
Type of stents			
Zilver Vena (COOK medical)	13	9	0.2*
	59.1%	40.9%	
WALLSTENT (Boston Scientific)	7	11	
	38.9%	61.1%	
Procedure-related adverse events			
No	19	15	0.06**
	55.9%	44.1%	
Yes	1	5	
	16.7%	83.3%	

IVUS, intravascular ultrasound. **P*-value calculated using Chi square test. ***P*-value calculated using Liklihood ratio.

Table 5 Background medical data for the whole study population

	n (%)
Sex	
Male	29 (72.5)
Female	11 (27.5)
Smoking	
No	17 (42.5)
Yes	23 (57.5)
Obesity	
No	27 (67.5)
Yes	13 (32.5)
Diabetes	
No	31 (77.5)
Yes	9 (22.5)
Hypertension	
No	27 (67.5)
Yes	13 (32.5)
Hypercholesterolemia	
No	29 (72.5)
Yes	11 (27.5)
ISHD previous stroke	
No	40 (100)
No	40 (100)
Chronic renal impairment	
No	40 (100)

venography group (P=0.014 and P<0.0001, respectively) (Tables 9–12). Preoperative lesion site and type were not found to be statistically significant between the two groups, with a P value of 0.12 and 0.4, respectively, which excludes lesion characteristics from being a confounding factor despite randomization. Postoperative creatinine was significantly less in the IVUS group with a mean of 1.014 mg/dl (P<0.0001), and the mean increase in serum creatinine was 0.059 mg/dl in IVUS group and 0.242 in venography group, and this was statistically significant (P<0.0001), which means that IVUS leads to less contrast injection and less renal affection (Tables 13 and 14).

On comparing outcome between the two groups, target lesion revascularization was significantly higher in venography group, with a P value of 0.002, and although there was an overall statistically significant improvement in VCSS in both groups, it was more obvious and significant in the IVUS group compared with the venography group at 6- and 12-month follow-up (P=0.021 and 0.03, respectively) (Tables 15 and 16, 13).

Table 6 Preoperative baseline investigations for the whole study population

	Mean	SD
TLC	13 500	3200
PLT	373	65
CRP	54.2	29
ESR	79.12	34.74
HBA1C	5.08	0.54
Creatinine	0.89	0.26
BUN	12.625	5.85
ALT	19.12	5.5
AST	25.5	5.75
PT	30.7	28.5
PTT	36.3	34.5
INR	1.25	0.097

ALT, alanine aminotransferase; AST, aspartate aminotransferase; BUN, blood urea nitrogen; CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; HBA1C, glycated hemoglobin; INR, international normalized ratio; PLT, platelet; PT, prothrombin time; PTT, partial thromboplastin time; TLC, total leukocyte count.

Table 7 Preoperative imaging and presenting symptoms for the whole study population

	n (%)
Preoperative duplex lesion type	
Stenosis	14 (35)
Occlusion	24 (60)
NAD	2 (5)
Preoperative duplex lesion site	
Common iliac vein	2 (5)
External iliac vein	5 (12.5)
Common femoral vein	10 (25)
Common and external iliac veins	5 (12.5)
Common iliac, external iliac, and common femoral vein	4 (10)
External iliac vein and common femoral vein	12 (30)
NAD	2 (5)
Diagnostic IVUS	
No	20 (50)
Yes	20 (50)
Venous claudication	
Yes	40 (100)
Pigmentation	
No	21 (52.5)
Yes	19 (47.5)
Venous ulcer	
No	33 (82.5)
Yes	7 (17.5)
Associated peripheral ischemia	
No	37 (92.5)
Yes	3 (7.5)
Pain	
Daily	16 (40)
Daily with medication	24 (60)
Varicose veins	
Absent	7 (17.5)

(*Continued*)

Table 7 (***Continued***)

	n (%)
Few	22 (55)
Multiple	8 (20)
Extensive	3 (7.5)
Venous edema	
Evening only	1 (2.5)
Afternoon	12 (30)
Morning	27 (67.5)
Pigmentation	
None	20 (50)
Limited and old	2 (5)
Diffuse and more recent	12 (30)
Wide and recent	6 (15)
Inflammation	
None	15 (37.5)
Mild cellulitis	12 (30)
Moderate cellulitis	8 (20)
Severe cellulitis	5 (12.5)
Induration	
None	23 (57.5)
Focal <5 cm	7 (17.5)
<1/3 gaiter	7 (17.5)
>1/3 gaiter	3 (7.5)
Active ulcers	
None	33 (82.5)
1	4 (10)
2	1 (2.5)
>2	2 (5)
Ulcer duration	
None	33 (82.5)
<3 months	1 (2.5)
3–12 months	6 (15)
Ulcer size	
None	33 (82.5)
2–6 cm	6 (15)
>6 cm	1 (2.5)

IVUS, intravascular ultrasound.

Regarding evaluating the diagnostic ability of IVUS to detect significant lesions compared with conventional venography in the IVUS group (where both IVUS and venography were done), IVUS was found to be significantly superior than venography, being able to diagnose a mean of 2.75 significant lesions (SD 0.79) compared with a mean of 1.6 lesions through venography (SD 0.76), which was found to be statistically significant, with a *P* value of less than 0.0001 (Table 5). Moreover, IVUS was more able to detect stenoses and occlusions than CT venography during follow-up, with a *P* value of .018 (Tables 17 and 10).

Table 8 Follow-up venous clinical severity scoring

	Mean	SD
VCSS	20	6
VCSS at 1 month	14	4
VCSS at 3 months	9	3
VCSS at 6 months	7	2
Ulcer healing duration in months	4.7	2.25
	Median	IQR
VCSS at 12 months	5	5
Time to TLR in months	9	17

TLR, target lesion revascularization; VCSS, venous clinical severity scoring.

On exploring the patency using Kaplan–Meier curve, IVUS groups showed a statistically significant higher primary assisted patency rate compared with venography, with a *P* value of 0.017 (Fig. 1).

Discussion

The evidence summarized in the current study brings to light that IVUS added extremely pivotal information, principally regarding the number, pattern, and types of vascular lesions within the venous system that represented a major challenge in dealing with CVI. Such advantages made it a valuable diagnostic tool for evaluating the extent and severity of iliofemoral CVI. Employment of such findings in the health care systems will reflect considerably on the short-term and long-term outcomes.

Accurate identification and reliable measurement of the extent and severity of venous lesions is of utmost importance and critical need for vascular surgeons. In the present study, the mean number of lesions which were recognized by IVUS was significantly higher than venography. Precisely, IVUS succeeded in the detection of 23 lesions, which were not detectable based on multiplanar venography alone. Moreover, IVUS identified six occlusive lesions, which were distinguished as stenotic lesions based on venography. This information allowed a precise adaptation of the treatment plan, giving each patient the safest, effective, and appropriate intervention.

The findings in our study are consistent with numerous studies such as the VIDIO (venography vs. IVUS for diagnosing and treating iliofemoral vein obstruction) trial, where both IVUS and multiplanar venography were performed to 100 patients. The investigators found that venography successfully detected 51 lesions compared with 81 lesions detected by IVUS, in addition to the underestimation of the severity of lesions in venography by 11% compared with IVUS ($P<0.001$) [9].

Table 9 Association of background medical data between intravascular ultrasound and venography groups

	Group		
	IVUS	Venography	*P* value
Sex			
Male	17	12	0.077*
	58.6%	41.4	
Female	3	8	
	27.3%	72.7%	
Smoking			
No	7	10	0.34*
	41.2%	58.8%	
Yes	13	10	
	56.5%	50%	
Obesity			
No	16	11	0.091*
	59.3%	40.7%	
Yes	4	9	
	30.8%	69.2%	
Diabetes			
No	18	13	0.05**
	58.1%	41.9%	
Yes	2	7	
	22.2%	77.8%	
Hypertension			
No	15	12	0.31*
	55.6%	44.4%	
Yes	5	8	
	38.5%	61.5%	
Hypercholesterolemia			
No	16	13	0.28*
	55.2%	44.8%	
Yes	4	7	
	36.4%	63.6%	
Recurrent DVT			
No	13	12	0.74*
	52%	48%	
Yes	7	8	
	46.7%	53.3%	

DVT, deep vein thrombosis; IVUS, intravascular ultrasound. **P*-value calculated using Chi square test. ***P*-value calculated using Liklihood ratio.

This fact was acknowledged by Lau and colleagues who investigated the means of improving the sensitivity of venography in detection and assessment of lesions by relying on multiple venographic findings, including collaterals, pancaking, and contrast thinning in venography, and comparing them with IVUS. Despite their promising findings, they concluded that although anteroposterior venography can indirectly diagnose venous obstruction, they still recommended the use of IVUS owing to the better sensitivity and more precise intervention planning [4].

It is important to emphasize that patients within multiplanar venography were subjected to a

Table 10 Comparing mean vales of background medical data between the two groups

	Group	*N*	Mean	SD	*P* value**	Difference
Age	IVUS	20	45.45	11.852	0.144	−5.750
	Venography	20	51.20	12.484		
Number of days since last DVT	IVUS	20	390.50	673.236	0.361	141.500
	Venography	20	249.00	59.639		
TLC	IVUS	20	10.050	2.8419	0.598	−0.5000
	Venography	20	10.550	3.0946		
PLT	IVUS	20	285.850	87.6208	0.652	−11.5500
	Venography	20	297.400	72.0266		
CRP	IVUS	20	21.165	23.4785	0.812	−1.9450
	Venography	20	23.110	27.6944		
ESR	IVUS	20	36.600	28.5480	0.866	−1.7000
	Venography	20	38.300	34.4935		
HBA1C	IVUS	20	5.105	1.1741	0.033	−1.0000
	Venography	20	6.105	1.6363		
Creatinine	IVUS	20	0.955	0.2010	0.519	−0.0420
	Venography	20	0.997	0.2073		
BUN	IVUS	20	12.800	4.3237	0.040	−3.2000
	Venography	20	16.000	5.1504		
ALT	IVUS	20	15.850	4.6597	0.650	−0.7500
	Venography	20	16.600	5.6606		
AST	IVUS	20	18.850	6.8154	0.261	−2.3605
	Venography	19	21.211	6.0789		
PT	IVUS	20	28.750	4.4352	0.576	0.8000
	Venography	20	27.950	4.5245		
PTT	IVUS	20	33.200	5.1360	0.873	0.2500
	Venography	20	32.950	4.7069		
INR	IVUS	20	1.125	0.2025	0.770	0.0170
	Venography	20	1.108	0.1600		
	Venography	20	2.35	0.875		

ALT, alanine aminotransferase; AST, aspartate aminotransferase; BUN, blood urea nitrogen; CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; HBA1C, glycated hemoglobin; INR, international normalized ratio; PLT, platelet; PT, prothrombin time; PTT, partial thromboplastin time; TLC, total leukocyte count. ***P* value calculated using independent samples *t* test.

Table 11 Comparing mean vales of intraoperative details between the two groups

	Group	*N*	Mean	SD	*P* value**	Mean difference
Largest sheath diameter	IVUS	20	8	2	0.471	0.350
	Venography	20	8	1		
Number of stents deployed	IVUS	20	2.35	0.587	0.768	0.050
	Venography	20	2.30	.470		
Amount of contrast injected (ml)	IVUS	20	33.50	10.400	0.000	−103.500
	Venography	20	137.00	20.026		
Duration of the procedure (min)	IVUS	20	111.50	35.433	0.014	−27.500
	Venography	20	139.00	31.937		

IVUS, intravascular ultrasound. ***P* value calculated using independent samples *t* test.

considerably higher dose of radiation and contrast (mean of 137 ml), relative to those within IVUS group (mean of 35.5 ml, P=0.035). This is because, the appropriate demonstration of venous lesions necessitated good concentration of the contrast material in addition to more frequent subtraction angiographies from different angles. This finding was reflected on the kidney functions in the long-term outcomes. Despite being within normal range preoperatively, the mean level of creatine was significantly higher among patients diagnosed with venography postoperatively.

It should also be mentioned that the procedure duration was significantly shorter among patients within the IVUS group in comparison with patients within the venography group. Given the limited diagnostic capability of venography and related risks, using IVUS decreased the exposure to radiation and contrast volume besides being an accurate diagnostic tool.

Table 12 Comparing mean vales of venous clinical severity scoring score between the two groups

	Group	*N*	Mean	SD	*P* value**	Mean difference
Baseline VCSS	IVUS	20	12	5	0.515	–1.100
	Venography	20	13.00	6		
VCSS at 1 month	IVUS	20	8	3	0.175	–1.650
	Venography	20	10	4		
VCSS at 3 months	IVUS	20	6	2	0.129	–1.150
	Venography	20	7	3		
VCSS at 6 months	IVUS	20	5	1	0.021	–1.450
	Venography	20	6	2		
VCSS at 12 months	IVUS	20	5	2	0.035	–1.700
	Venography	20	6	3		

IVUS, intravascular ultrasound; VCSS, venous clinical severity scoring. ***P* value calculated using independent samples *t* test.

Table 13 Comparing mean values of preoperative and postoperative serum creatinine in both groups

	Group	*N*	Mean	SD	*P* value**
Preoperative creatinine	IVUS	20	0.955	0.2010	0.519
	Venography	20	0.997	0.2073	
Postoperative creatinine	IVUS	20	1.014	0.1940	$<$0.0001
	Venography	20	1.239	0.1565	

IVUS, intravascular ultrasound. ***P* value calculated using independent sample *t* test.

Table 14 Comparing mean vales of follow up data between the 2 groups

	Group	N	Mean	Std. deviation	*P*-value**	Mean difference
Time to TLR in months	IVUS	20	3.15	6.115		
	Venography	20	24.10	68.070	.186	–20.950
Ulcer healing duration inMonths	IVUS	3	3.33	1.528		
	Venography	5	5.60	2.302	.147	–2.267
Post-operative creatinine	IVUS	20	1.014	.1940		
	Venography	20	1.239	.1565	.000	–.2250

It is pivotal to put into consideration the imperative role of clinical assessment, patient history, and radiological findings all together before the individualization of the treatment plan. In addition, the role of multiplanar venography in the management plan of iliofemoral CVI cannot be neglected. Venography remains a desirable adjunct in iliac vein stenting, as it allows a panoramic view of the pathologic process, particularly the collaterals. Moreover, IVUS may provide a partial image of particular lesions, principally those situated at the iliac-caval confluences, and therefore, the role of venography cannot be completely omitted [10].

The long-term outcomes of iliofemoral CVI necessitated the move toward a more meticulous identification and treatment method for venous pathologies. In this study, patients within the venography group experienced five-folds more procedure-related adverse events compared with IVUS. Moreover, after the first postoperative 12 months, 45% within the venography group had residual venous stenosis or occlusion, in contrast to 15% in the IVUS group. Patients within venography group had statistically significant higher levels of VCSS at 12 months in comparison with patients within IVUS group. Our study also demonstrated a superior ability of IVUS to diagnose occlusive and stenotic lesions during follow-up compared with CT venography, which further expounds the crucial role of IVUS in the prognosis and follow-up of patients with venous insufficiency.

Conclusion

IVUS is one of the most effective tools in the armamentarium of a vascular surgeon and interventionalist, especially when dealing with venous disorders. When it comes to using IVUS in patients with CVI, our study suggests that as an imaging modality, it provides more sensitive and accurate details of the lesion, aids in setting a more appropriate plan, guides the surgeon through a more precise sizing and deployment of the necessary stents, and finally, provides a better follow-up tool to detect and guide subsequent interventions, resulting in higher primary assisted and secondary patency rates. The integration of these findings, along with the clinical manifestations of the condition, might help vascular surgeons to stratify the patients to the most appropriate and effective treatment modality,

Table 15 Association of postoperative anticoagulation and follow-up between intravascular ultrasound and venography groups

	Group		
	IVUS	Venography	*P* value
Postoperative anticoagulation			
No	4	7	0.28**
	36.4%	63.6%	
Yes	16	13	
	55.2%	44.8%	
Duplex findings at 1 month			
Patent	20	20	–
	50.0%	50.0%	
Duplex findings at 3 months			
Patent	20	19	0.23**
	51.3%	48.7%	
Thrombosed	0	1	
	0.0%	100.0%	
Duplex findings at 6 months			
Patent	19	16	0.338**
	54.3%	45.7%	
Stenosed	0	1	
	0.0%	100.0%	
Thrombosed (fresh thrombus)	1	2	
	33.3%	66.7%	
Occluded	0	1	
	0.0%	100.0%	
Duplex findings at 12 months			
Patent	17	11	0.154**
	60.7%	39.3%	
Stenosed	1	1	
	50.0%	50.0%	
Thrombosed (fresh thrombus)	1	3	
	25.0%	75.0%	
Occluded	1	5	
	16.7%	83.3%	
TLR			
No	15	5	0.002*
	75.0%	25.0%	
Yes	5	15	
	25.0%	75.0%	
Type of TLR			
No	15	5	0.004**
	75.0%	25.0%	
Balloon dilatation	2	6	
	25.0%	75.0%	
Thrombolysis followed by balloon dilatation	0	4	
	0.0%	100.0%	
Thrombolysis followed by balloon dilatation and stenting	1	0	
	100.0%	0.0%	
Failure of reintervention	2	5	
	28.6%	71.4%	
Ulcer healing			
Yes	3	5	–
	37.5%	62.5%	

IVUS, intravascular ultrasound; TLR, target lesion revascularization. **P*-value calculated using Chi square test. ***P*-value calculated using Liklihood ratio.

Table 16 Comparing mean vales of follow-up data between the two groups

	Group	*N*	Mean	SD	*P* value**	Mean difference
Time to TLR in months	IVUS	20	3.15	6.115	0.186	–20.950
	Venography	20	24.10	68.070		
Ulcer healing duration (months)	IVUS	3	3.33	1.528	0.147	–2.267
	Venography	5	5.60	2.302		
Postoperative creatinine	IVUS	20	1.014	0.1940	0.000	–0.2250
	Venography	20	1.239	.1565		

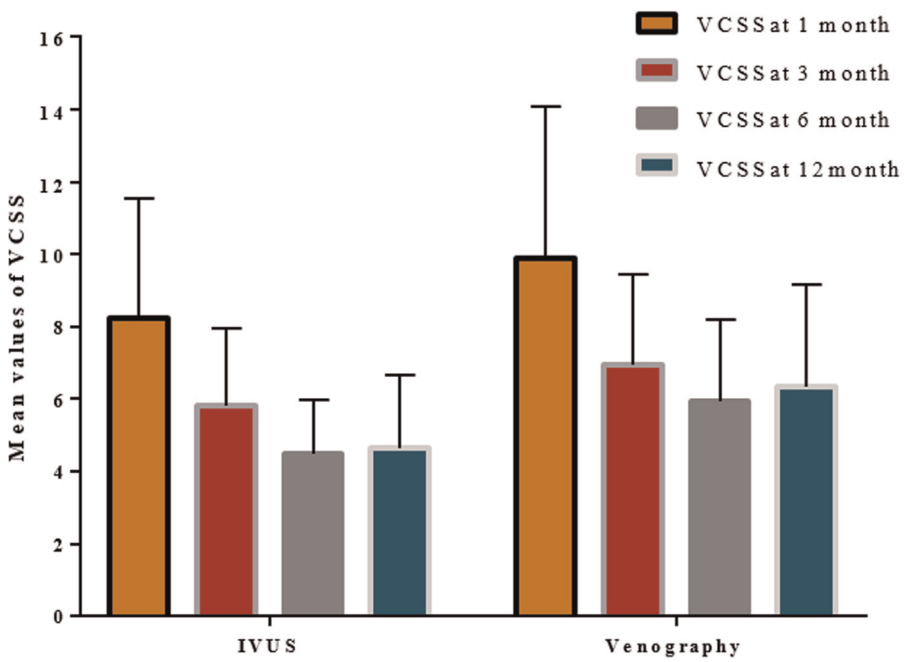
IVUS, intravascular ultrasound; TLR, target lesion revascularization. ***P* value calculated using independent samples *t* test.

Table 17 Comparing mean number of lesions detected by intravascular ultrasound compared with venography

	Mean	SD	*T*	*P* value**
Number of lesions detected by IVUS	2.75	0.786	6.328	$<$0.0001
Number of lesions detected by venography	1.60	0.754		

IVUS, intravascular ultrasound. ***P* value calculated using paired samples *t* test.

Figure 2



Error bar chart showing venous clinical severity scores at different time intervals.

Table 18 Association between types of lesions detected by intravascular ultrasound and those detected by computed tomography venography at 18 months

	Computed tomography venography at 18 months			
	Patent	Stenosed	Occluded	*P* value
IVUS at 18 months				
Patent	16	0	0	0.018**
	100.0%	0.0%	0.0%	
Stenosed	2	1	0	
	66.7%	33.3%	0.0%	
Occluded	0	0	1	
	0.0%	0.0%	100.0%	

IVUS, intravascular ultrasound. ***P* value calculated using likelihood ratio.

plan, and execution. Newer and smaller caliber IVUS fibers along with better diagnostic accuracy and range are in dire need to make the use of IVUS more feasible and less invasive, and eventually overcome the major inconvenience associated with its use (Fig. 2 and Table 18).

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Conflicts of interest

There are no conflicts of interest.

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