A prospective cohort study bespeaking the sequel of popliteal vein distension on the clinical severity of primary chronic venous insufficiency as shown by venous Doppler ultrasound

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Background
Chronic venous insufficiency (CVI) is a condition caused by retrograde flow of venous blood that is attributed to several factors, the most important of them is damaged venous valves. Recent studies have suggested that the popliteal-vein (PV) diameter has a vital role in the vastness of lower-limb CVI. Doppler ultrasound (DUS) is considered the mainstay noninvasive imaging modality for the diagnosis of peripheral vascular disorders.

Objective
The target of our study was to point out the relation between the clinical severity of primary CVI and PV condition evaluated by DUS.

Patients and methods
In total, 50 limbs of 25 consecutive patients (14 women and 11 men; age range, 25–85 years) with clinical diagnosis of CVI were graded according to the Clinical Etiological Anatomical Pathological classification and then examined by DUS for estimation of PV diameter and venous reflux. In each limb, the clinical grade of CVI was then compared with the DUS findings. Data were collected and analyzed using SPSS, version 20 and statistical significance was set at *P* value less than 0.05.

Results
The mean PV diameter was 1.3 cm. No reflux was observed in limbs with PV diameter less than 6 mm. Reflux was detected at the femoropopliteal junction in 22% of the examined limbs with the highest frequency at PV diameter more than 9 mm. There was a direct association between the PV diameter and the clinical severity of CVI. An increased PV diameter was affiliated with higher frequency and velocity of reflux at the femoropopliteal junction, which were consequently associated with higher Clinical Etiological Anatomical Pathological grades.

Conclusion
There was a significant correlation between the clinical grades of CVI-enhanced and DUS-evaluated PV condition. The degree of the increase in the PV diameter can reflect the severity of CVI.

Keywords:
chronic venous insufficiency, Doppler ultrasonography, popliteal vein

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Introduction

The term 'chronic venous insufficiency' (CVI) describes a condition that affects the venous system of the lower extremities with venous hypertension causing various pathologies. Chronic venous disease is frequently unnoticed by healthcare providers because of an underestimation of the extent and results of the issue [1].

The lower-limb veins are composed of two interconnected draining systems: deep and superficial systems, connected by the perforating veins that regulate the blood flow from the superficial to the deep veins [2]. There are about 200 bicuspid valves in the venous system of each lower limb directing blood flow toward the heart. Venous-valve abnormalities lead to blood reflux with reversed pressure and consequently tenacious venous distension [3].

Manifestations of CVI include dilated bluish veins and limb swelling with feeling of heaviness and aching pain in the legs and feet that maybe associated with skin discoloration, itching, or leg cramps that can limit activities. Symptoms get worse by sitting or standing for long periods [4–6].

In order to perform an accurate diagnosis and then correct treatment of CVI, the Clinical Etiological Anatomical Pathological (CEAP) classification is now accepted as a worldwide standard for classifying chronic venous disorders [7,8].

Formerly, it has been accepted that in case of lower-limb valvular incompetence, varicose veins begins at the saphenofemoral junction and progresses in a descending fashion. But, recent studies have suggested the possibility of distal origin of incompetence and reflux with a subsequent ascending progression [9].

Popliteal vein (PV) is one of the main units constituting the limb lower deep venous system, which has proficient venous valves that guard against infrapatellar deep venous insufficiency, and its inadequacy has been associated with severe grades of CVI [10–13].

Doppler ultrasound (DUS) provides an accurate graphic representation of the deep and superficial venous systems and can establish the diagnosis of CVI by evaluation of venous anatomy and diameter. It has many advantages over other methods, including being an easily available, quick, noninvasive, and tolerable imaging modality that does not involve radiation exposure, so it can be performed as frequent as necessary [14].

Venous duplex imaging combines B-mode imaging of the deep and superficial veins with pulsed Doppler assessment of flow. This provides information about the anatomic extent of disease involving the deep and superficial systems, as well as perforators [15].

When conducted by an expert radiologist, DUS can provide reliable measurements of venous diameter and reflux and consequently can point out the scope and distribution of venous disease [14]. Nowadays, DUS is considered essential for preoperative and postoperative assessment of CVI patients [16].

The target of our study was to point out the relation between the clinical severity of primary CVI and the PV diameter as evaluated by DUS.

Patients and methods

The study protocol was approved and monitored by the Medical Ethics Committee, Faculty of Medicine, Assiut university (IRB: 17100991). Written informed consent was obtained from all patients after receiving the necessary information from the examiner.

Our study included 50 limbs of 25 consecutive patients referred to the Radio-diagnosis Department from outpatients of vascular surgery with manifestations of CVI. Both sexes with age range between 25 and 85 years were enrolled. Exclusion criteria were superficial thrombophlebitis, deep venous thrombosis, or recurrent CVI after previous lower-limb venous interventions.

Detailed history was obtained from each patient followed by visual assessment of the leg to be examined. Based on the clinical symptoms and signs, the limbs were classified according to the CEAP classification system, which is a comprehensive classification system in which seven clinical groups are recognized, depending on description of the clinical class (C) based on the objective signs, the etiology (E), the anatomical (A) distribution of reflux and obstruction in the superficial, deep, and perforating veins, and the underlying pathophysiology (P), whether due to reflux or obstruction. The clinical grades are divided as follows [8]:

C0: no visible or palpable signs of venous disease.

C1: telangiectasias and reticular veins. C2: varicose veins. C3: edema. C4a: brown pigmentation (ochre dermatitis) and/or eczema. C4b: lipodermatosclerosis or athrophie blanche. C5: healed venous ulcer. C6: active venous ulcer.

DUS examinations were conducted on Logic GE P6, Windows operating system using 7–12-MHz linear-array transducer. After good hydration, scanning was performed with the patient standing on the examination table facing the examiner. The examined limb was relaxed, externally rotated, and slightly flexed at the knee while the patient's weight on the contralateral limb. In patients who were unable to stand, the veins from the mid-thigh and below were assessed in the sitting position.

The venous system of each limb was assessed first by grayscale ultrasound evaluation to evaluate the wall thickness and smoothness, compressibility, phasicity, and nonpulsitality. Then, Duplex interrogation was performed at many levels to ensure a complete examination based on the clinical indications. Doppler examination was used to assess the color fill of the vein with the presence or absence of defects on color flow and to test the venous competence (reflux).

Multiple longitudinal and transverse views were required to evaluate the PV. The PV was examined both in the supine position and with the patient standing where phasicity of flow with respiration was observed.

The main variables were venous reflux at the femoropopliteal junction (FPJ) and PV diameter at multiple orientations, then, the mean PV diameter was calculated. If reflux was detected, its time and velocity would be measured.

Venous reflux was evaluated at the FPJ during manual calf-muscle compression distal to the transducer. Usually, blood flow stops in the deep veins by this

procedure after a retrograde flow of 1 s or less. Perforating vein with a diameter more than 0.35 cm or a retrograde time longer than 0.5 s was considered insufficient. The DUS findings of each lower-limb PV were then correlated with its clinical grade of CVI.

The criterion standard of the study group was the CEAP classification, against which DUS findings were compared.

Statistical analysis

Data were collected and analyzed using SPSS (Statistical Package for the Social Science, version 20; IBM, Armonk, New York, USA). Continuous data were expressed in the form of mean ± SD or median (range), while nominal data were presented in the form of frequency (percentage). χ^2 test was used to compare the nominal data of different groups, whereas Student *t* test was performed in case of continuous data. The level of confidence was kept at 95% and *P* value less than 0.05 was considered significant.

Results

The study included 50 limbs of 25 patients with mean age of 55.67 ± 12.34 years and range between 25 and 85 years (Fig. 1). The majority (75%) of patients of the study were 40 years or older. Female patients represented 56% (*n* = 14) of the study group with eight of them who were multigravida and 10 used hormonal contraception (Fig. 2). Positive family history was noted in 52% of the patients, while 76% of our population had cardiac disease.

According to severity of clinical manifestations, limbs were divided into two groups: group I that included 24 limbs with mild symptoms (C0–3) and group II formed 26 limbs with moderate-to-severe symptoms (C4–6).

Based on DUS findings, the mean PV diameter in our study was 1.3 cm, with range from 0.5 to 1.8 cm. No venous reflux was detected in limbs with PV diameter less than 0.6 cm, which was defined as the normal diameter.

Reflux at the FPJ was detected in 11 (22%) of the examined limbs that have PV diameter more than or equal to 0.6 cm. There was direct association between PV diameter and frequency of venous reflux where eight out of the 11 limbs with reflux had PV diameter more than 0.9 cm (Table 1). Also, an increased PV diameter was associated with increased reflux time and velocity. According to PV diameter, limbs with reflux were divided into three groups: those with mild, moderate, or severe reflux (Table 2). Mild perforating-vein insufficiency was present in six (12%) limbs.

Correlation between the DUS findings of PV and the clinical grades of CVI revealed statistically significant differences between the two clinical groups regarding PV diameter, frequency of reflux, reflux time, and peak reflux velocity (Table 3 and Figs. 3–5).

Discussion

CVI is a worldwide condition having several drawbacks on patient's quality of life and also on healthcare

Table 1 Frequency of femoropopliteal reflux based on popliteal-vein diameter

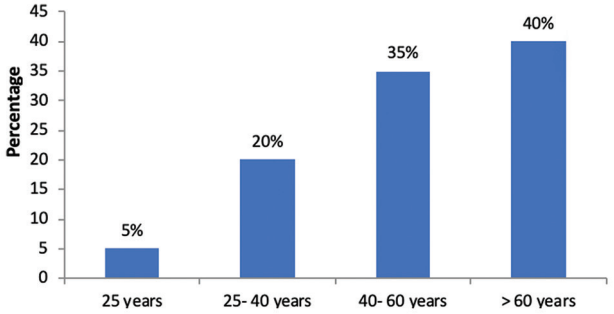
PV diameters (cm)	With reflux (*n*=11)	Without reflux (*n*=39)	*P*
<0.6	0	24 (61.5)	
0.6-0.9	3 (27.3)	11 (28.2)	<0.001
0.91-1.2	6 (54.5)	2 (5.1)	
1.2-1.8	2 (18.18)	2 (5.1)	

Data were expressed in the form of *n* (%). PV, popliteal vein. *P* value was significant if less than 0.05.

Table 2 Grading of femoropopliteal reflux according to popliteal-vein diameter

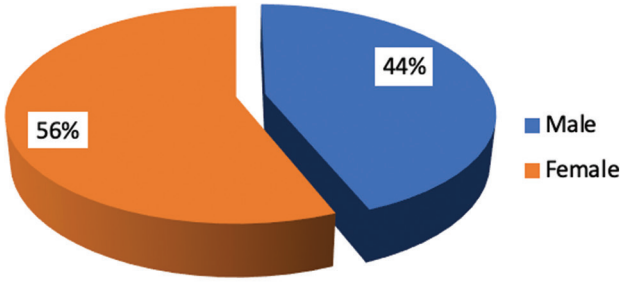
Reflux	Popliteal-vein diameter (cm)
No reflux (39 limbs, 78%)	<0.6
Mild (3 limbs, 27.3%)	0.6-0.9
Moderate (6 limbs, 54.5%)	>0.9-1.8
Sever (2 limbs, 18.1%)	>1.8

Figure 1



Bar chart showing age groups of studied patients.

Figure 2



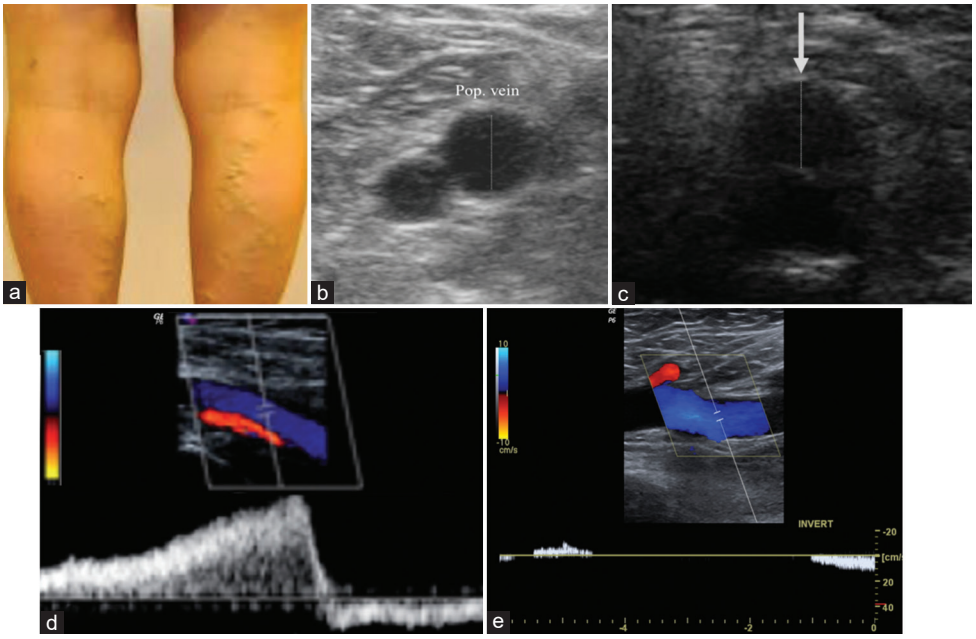
Pie chart showing sex distribution of the study.

Table 3 Correlation of clinical manifestations with Doppler ultrasound findings

	Group I (mild symptoms, C0-3)	Group II (moderate-to-severe symptoms, C4-6)	*P*
PV diameter (cm)	0.6-0.9	>0.9	<0.001
Frequency of reflux	3 (27.3)	8 (72.7)	0.03
Reflux time (s)	0.5±0.5	1.70±0.69	<0.001
Peak reflux velocity (cm/s)	16.50±2.12	29±4.01	<0.001

PV, popliteal vein.

Figure 3



(a) Dilated tortuous veins. Axial-view DUS showing (b) the right popliteal-vein diameter (1.2 cm). (c) Left popliteal-vein diameter (0.8). (d) Refluxing right popliteal vein in response to distal augmentation. (e) Nonrefluxing left popliteal vein. DUS, Doppler ultrasound.

resources, because it can progress to severe degrees of morbidity requiring extensive treatment [17]. Lower-limb varicose veins are identified as dilated, tortuous, elongated veins on the skin surface, especially on the legs. The problem may range from few cosmetic complaints in young individuals to venous ulceration in the elderly [18].

DUS is considered the gold standard for diagnosis of peripheral venous disease. It combines the advantages of grayscale and color Doppler examination in a painless noninvasive manner to image the blood vessels of the body [18,19].

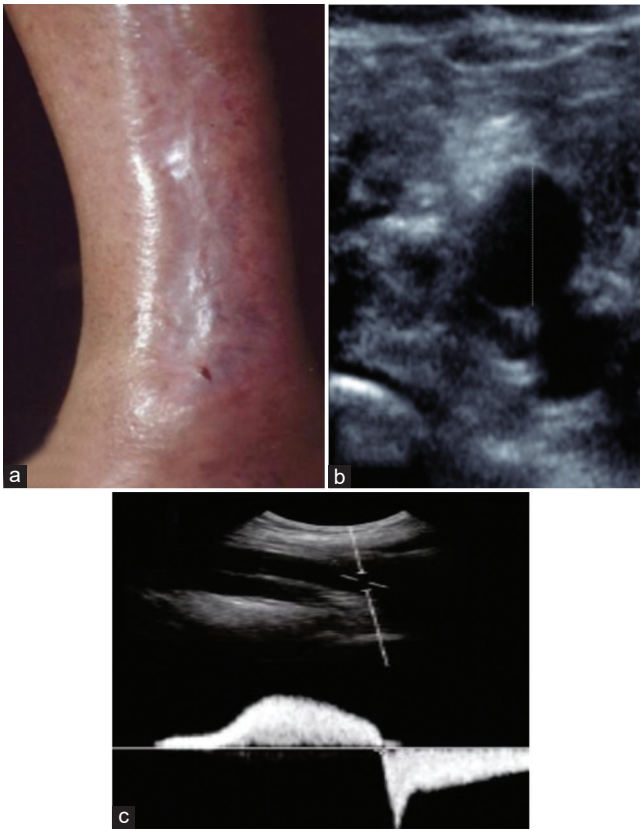
The mean age of our study population was 55 years with range between 25 and 85 years and 75% of patients were more than or equal to 40 years. In this result, we are in agreement with Meissner *et al.* [20], who concluded increased incidence of CVI with aging, which could be due to decreased mobility, reduced venous compliance in the calf, and damaged venous valves.

Most patients (56%) of the present work were females, which is consistent with Beebe-Dimmer *et al* [21], who stated that the prevalence of varicose veins ranged dramatically from 2–56% in males to less than 1–73% in females. This increased risk in women could be attributed to hormonal factors that are affected by pregnancy, use of hormonal contraceptives, and menopause [22]. This is correlated with our study results that approached the relationship between pregnancy and the use of hormonal contraception with CVI as evident by the increased CVI incidence in gravid women (32%) and in those who used hormonal contraception (40%). Sparey *et al.*[23] and Mullane[22] revealed similar results.

In the present study, it was noticed that 13 (52%) patients had positive family history of CVI showing a strong correlation between hereditary factors and CVI. In this topic, our results were similar to a study conducted by Serra *et al.* [24], depending on the recruitment of informative families, accurate determination of the phenotype of each family member, and blood sample for DNA extraction for genetic analysis.

In the current study, we found that 19 (76%) patients had cardiac disease, and this was associated with clinical grade C3–C5 that is more severe than other patients without systemic disease, mostly due to decreased

Figure 4



(a) Limb discoloration with healed venous ulcer. Axial-view DUS showing (b) the left popliteal-vein diameter (1.4), (c) refluxing left popliteal vein in response to distal augmentation.

cardiac contractility causing pooling of blood in the peripheral veins, leading to their dilatation [15].

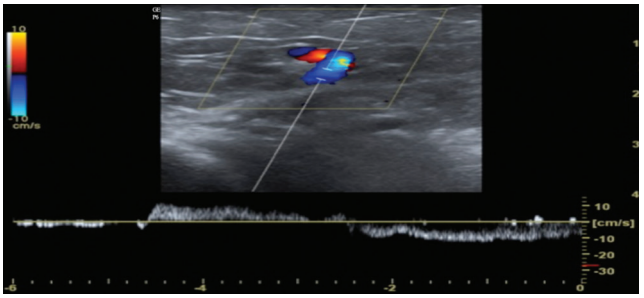
Previous studies have concluded that deep venous insufficiency secondary to deep valvular incompetence is associated with higher grade of CVI. The majority of patients with score C6 (active venous ulcer) had deep venous insufficiency [25].

The results of the current work demonstrated a direct association between venous reflux and increased venous diameter. Also, an increase in the vein diameter was consequently followed by a greater reflux proportion, both in superficial and deep venous systems, leading to a deterioration of the CEAP grading. The cutoff value of PV diameter for predicting pathological is more than 6 mm.

In the calf, the state of the PV is the predominating factor affecting the severity of CVI, as it is the point at which the various venous-system components unite. Therefore, the increase in its diameter is a sign of the magnitude of venous insufficiency [26].

Our study reported mean PV diameter of 1.3 cm, the venous diameter varied a little when measured in different positions on DUS. The frequency of reflux

Figure 5



Dilated refluxing Boyd's perforator in the right lower limb. DUS, Doppler ultrasound.

in the deep and superficial systems increased as PV diameter increased.

When evaluating the PV diameter, the present data showed 11 (22%) cases with reflux, while 39 (78%) cases were normal. Reflux at the FPJ in these cases was divided into mild reflux in three (27.3%) limbs, moderate reflux in six (54.5%) limbs, and sever reflux in two (18.1%) limbs.

Abreu *et al.*[2] addressed the impact of the PV diameter on the CEAP score of patients and found that the mean diameter of the PV in the group under study was 1.14 cm, almost double the mean diameter in the general population, demonstrating the magnitude of venous insufficiency.

A clinical trial conducted by Porto *et al.*[27] used PV diameter as one of its chief study parameters and focused on evaluating the effect of correcting PV pathology on the clinical picture in patients with CVI; the authors then found a decrease in PV diameter when treatment was successful with improvement of patient symptoms [28].

The increase in PV diameter points out to the magnitude of the venous insufficiency. Previous studies conducted by Baliyan *et al.*[29] and Labropoulos *et al.*[28] have shown the relation between the PV diameter and the clinical severity of CVI, also they have shown a close relationship between the increasing PV diameter and the high incidence of venous ulcer formation.

PV diameter appears to have an effect upon the size of the venous ulcer, where the mean increase in PV diameter is followed by an increase in the venous ulcer area, hence, the greater the PV diameter, the greater the ulcer size [30].

Conclusion

The prevalence of venous insufficiency in the FPJ in our study group is 22%, patients with reflux in the FPJ

were associated with greater morbidity and higher CEAP scores. Mean diameter of the PV in the study group was 1.3 cm, almost as twice as much the mean diameter in population. The enlarging venous diameter is mostly due to building up of retrograde pressure in the erect position and from venous dilatation at this level.

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Conflicts of interest
None declared.

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