

Doppler ultrasonography of the femoropopliteal segment in patients with venous ulcer

Avaliação do segmento venoso femoropoplíteo pela ultrassonografia Doppler em pacientes com úlcera varicosa

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Abstract

Background: Ulcer is a severe complication from chronic venous insufficiency; thus, its pathophysiology needs to be deeply understood. Venous Doppler ultrasonography is the most appropriate complementary imaging study, enabling the study of the superficial and deep venous system, the diameter and flow of the veins. Recent studies have suggested that popliteal vein reflux is an important factor for the development of ulceration.

Objective: To evaluate the venous reflux of the femoropopliteal segment in patients with venous ulcers.

Study design: Prevalence study.

Methods: Were enrolled 104 patients with 118 lower extremities with venous ulcers. Patients underwent Doppler ultrasonography of the affected limb showing the venous reflux of the femoropopliteal segment and popliteal vein diameter. Primary variable was venous reflux in the femoropopliteal segment; and secondary variable was diameter of the popliteal vein.

Results: Venous reflux in the femoropopliteal segment was observed in 56 of the 118 limbs with venous ulcer (47.45%) in 104 patients. The mean diameter of the popliteal vein was 1.14 cm, whereas 0.6 cm was the normal mean diameter of the population.

Conclusion: Venous reflux in the femoropopliteal segment is a major factor in assessing the prognosis of these patients. Increased diameter of the popliteal vein reflects the magnitude of venous insufficiency.

Keywords: venous ulcer; Doppler ultrasonography; popliteal vein.

Resumo

Contexto: Como a úlcera é uma grave complicação da insuficiência venosa crônica, é necessário o conhecimento amplo de sua fisiopatologia. A ultrassonografia Doppler venosa é o exame complementar mais adequado, que possibilita o estudo do sistema venoso superficial e profundo, sua anatomia e fisiologia. Trabalhos recentes valorizam o refluxo em Veia Poplítea como importante fator para o desenvolvimento deste quadro clínico.

Objetivo: Avaliar o refluxo em segmento venoso femoropoplíteo em pacientes com úlcera varicosa.

Tipo de Estudo: Estudo de prevalência.

Métodos: Cento e quatro pacientes apresentando 118 membros inferiores com úlcera varicosa. Procedimentos: exame de ultrassonografia Doppler venosa do membro acometido, observado o refluxo no segmento venoso femoropoplíteo e diâmetro da Veia Poplítea. Variáveis: Primária: refluxo no segmento venoso femoropoplíteo. Secundária: diâmetro da Veia Poplítea.

Resultados: A presença de refluxo no segmento venoso femoropoplíteo foi observada em 56 (47,45%) dos 118 membros com úlcera varicosa, examinados em 104 pacientes. O diâmetro médio da Veia Poplítea foi de 1,14 cm, sendo o diâmetro médio normal da população 0,6 cm.

Conclusão: O refluxo venoso no segmento venoso femoropoplíteo é um importante fator na avaliação do prognóstico destes pacientes, o aumento de diâmetro da Veia Poplítea reflete a magnitude da insuficiência venosa.

Palavras-chave: úlcera varicosa; ultrassonografia Doppler; Veia Poplítea.

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Introduction

The venous system of lower limbs has a deep and a superficial system, and the two are connected by the perforating veins, which direct the flow from the superficial to the deep veins towards the heart. The deep system is responsible for draining 85% of the blood flow of lower limbs, whereas the superficial system drains, with the help of valves that block reflux, about 15% of the flow in the ascending direction when in a standing position¹. There are 90 and 200 valves in the venous system of each lower limb; they are usually bicuspid and direct the flow to the heart². The physiological consequences of valve lesions are reflux and persistent venous distension due to retrograde pressure, particularly when standing³.

A venous leg ulcer, defined as an open wound between the knee and the ankle, usually at the level of the malleoli and which does not healed in four weeks⁴, is the most serious lesion in chronic venous insufficiency (CVI) of the lower extremities⁵ and affects 1% to 2% of the world population^{6,7}.

CVI is a set of signs and symptoms whose major physiopathological factor is chronic venous hypertension in the lower limb, commonly caused by valve incompetence that may affect the superficial, deep and perforating veins, together or separately⁷⁻¹⁰.

The relative importance of reflux in several sites of the superficial and deep systems in the physiopathology of venous ulcers remains unclear¹¹. In 10% to 50% of the patients with venous ulcers, incompetence is limited only to the superficial veins¹¹, whereas incompetent communicating veins are found in 70% to 100% of the cases¹². Numerous studies showed that deep vein reflux plays an important role in cases of ulceration¹³⁻¹⁵.

The popliteal vein (PV) is a component of the deep venous system, and its incompetence has been associated with difficulties in venous ulcer healing; studies have suggested that a PV with competent valves acts as a barrier against infrapatellar deep venous reflux^{12,13,16-18}.

Color Doppler ultrasound (DUS) is a noninvasive and painless method without collateral effects that may be performed as many times as necessary. It may be used to confirm a diagnosis by evaluating both vein diameter and anatomy, and it has a specific advantage over other methods in the accurate determination of venous disease distribution and extent¹⁹. Diameter and venous reflux measurements evaluated by DUS are reliable. The shape of vein cross section remains practically the same when in an anatomic position²⁰. DUS examination is part of both the preoperative workup for patients with venous ulcer and the evaluation for clinical follow-up²¹.

This study evaluated the prevalence of reflux in a femoropopliteal venous segment and the diameter of the PV in patients with venous ulcers.

Methods

Patients with venous ulcer confirmed by physical examination were recruited to undergo DUS scanning. The study included 104 patients and 118 limbs with venous ulcers, distributed as follows: 14 patients had ulcers in both legs; all ulcers were classified as CEAP C6. Patients were both men and women with no occlusions in the femoropopliteal segment (FPS), and all signed an informed consent term after receiving the necessary information from the author. Data were collected using a standardized form.

A formula to define sample size for finite populations²² was used, and the result was 103 individuals for a 2% proportion of venous ulcer in the population ($p = 0.02$), 98% of individuals without venous ulcer in the population ($q = 0.98$), 1.96 constant corresponding to the 95% confidence index and $p = 0.05$ ($95\%Z = 1.96$) and $d = 0.027$ constant corresponding to the population density in the city of Teresina, Brazil, which has 800,000 inhabitants (N).

Sample size estimation (size determination formula)²² (Equation 1):

$$n = \frac{z^2 \times p \times q \times N}{d^2 \times (N - 1) + Z^2 \times p \times q} = 103 \quad 1$$

DUS scanning was performed according to service routine: the patient was standing and facing the examiner; the limb to be examined was slightly bent and externally rotated; and weight was supported on the contralateral limb. The exam was performed using a color digital scanner (Logic⁺ 500, GE), Windows[®] operating system, and 4- to 10-MHz linear transducers. The venous system was evaluated, with special attention to the FPS, as well as the anteroposterior and latero-lateral aspects of the PV, whose measurements should be added up and divided by two to calculate mean diameter in each patient.

Venous reflux at the saphenofemoral junction (SFJ) was evaluated while the patient performed the Valsalva maneuver, and, in the other segments, while the examiner applied manual compression of the muscles distal to the transducer to produce and detect flow during the DUS study of the lower limbs in real time. Flow usually stops after these maneuvers; any time of up to 1 second may be classified as physiological for the deep veins, and for superficial and perforating veins, of up to 0.5 seconds. Perforating veins with a diameter greater than 0.35 cm are also classified as having insufficiency²³.

The primary variable was FPS reflux, the secondary, PV diameter, and complementary data were sex, age, time of ulcer activity, occupation, heredity, use of contraceptive hormones and form of administration, clinical conditions, ulcer diameter, deep vein thrombosis (DVT), great saphenous vein (GSV) insufficiency, perforating vein insufficiency.

Results

Fourteen patients were excluded from the study: two did not sign the informed consent term; eleven, who had lower extremity ulcers and varicose veins, also had comorbidities that might explain the lesion, such as collagenosis (five), ischemia (four), ankle brachial pressure lower than 0.9, and tegumentary leishmaniasis (two) diagnosed by means of biopsy and histopathology; and one patient with a psychiatric disorder, who was not cooperative. The study, therefore, included 104 patients, 14 with bilateral ulcers, at a total of 118 limbs.

Reflux in the FPS was found in 56 limbs (47.45%).

Mean PV diameter in this study was 1.14 cm: the smallest diameter was 0.62 cm, and the largest, 2.01 cm. Mean diameter in the population according to the literature ranges from 0.5 to 0.7 cm. In this study, the normal diameter was defined as 0.6 cm²⁰.

Sixty nine patients (75.96%) were women, and the women to men ratio were 3:1.

Patient age ranged from 31 to 80 years, and mean age was 53 years: in the group of patients 30 to 39 years old, there were 15 patients (15.38%), in the 40 to 49, twenty-three (22.11%), in the 50 to 59, thirty-one (30.76%), in the 60 to 69, twenty-eight (27.88%); in the 70 to 79, five (4.80%) and in the 80 to 89 group, two (1.92%).

The most prevalent occupation was farming, for 54 patients (51.92%), followed by 22 patients (21.15%) whose occupation was housekeeping, that is, they were housewives; 8 were salespeople (7.69%); there were also 4 seamstresses (3.84%), 3 civil servants (2.88%), 2 cooks (1.92%), 2 mechanics (1.92%), 2 teachers (1.92%), 2 hairdressers (1.92%), 2 masons (1.92%), 1 stevedore (0.96%), 1 baker (0.96%), and 1 health visitor (0.96%).

In the item about heredity, patients were asked whether their first degree relatives had varicose veins corresponding to CEAP clinical class 2 (C2) to 6 (C6), and 80 (76.92%) of the patients answered affirmatively.

The use of contraceptives was denied by 73 (92.4%) of the patients, and 6 (7.6%) reported using them, all orally.

The most prevalent symptom in the limb affected was pain, which was diffuse in 91 (87.5%) of the patients,

followed by leg heaviness in 90 (86.53%), pruritus in 89 (85.7%), burning sensation in 83 (79.80%), cramps in 83 (79.80%), fatigue in 76 (73.07%), and paresthesia in 67 (64.42%).

Ulcer diameter, measured in centimeters in two directions as the longer and the shorter distances between the internal margins, ranged from 1 to 12 centimeters, and mean diameter was 3 centimeters. These findings were used to calculate the area of each ulcer, which was then classified as small, when the area was smaller than 10 cm² (83 cases, 70.33%), medium, 10 to 100 cm² (32, 27.11%), and large, greater than 100 cm² (3, 2.5%).

In the analysis of previous deep venous thrombosis (DVT), 67 (64.42%) patients denied it, 20 (19.23%) reported having had at least one episode, and 17 (16.63%) did not know.

Total or segmental GSV insufficiency was seen in 98 (83.05%) limbs.

Perforating vein insufficiency was found in 79 (66.94%) limbs. Mean number of insufficient perforating veins was 2.5 for each patient.

Discussion

Chronic venous insufficiency (CVI) with leg ulceration, a disease found all over the world, has physical, social, economic and emotional consequences that may often lead to anxiety and depression, depending on its duration and the socioeconomic and cultural characteristics of the population under study²⁴. Ulcerations are defined as CEAP C6 - open venous ulcers²⁵.

Morbidity among patients with venous ulcers, as well as absenteeism and poor quality of life^{24,26,27}, is significant, particularly in the northeastern region of Brazil, where the hot climate and the exhausting working load for most of the population contribute to the worsening of this disease.

Doppler ultrasound (DUS), when combined with an evaluation of clinical characteristics, may be useful in making an accurate diagnosis of both functional and anatomic venous changes²⁸⁻³⁴, and the CEAP²⁵ classification provides an accurate diagnosis for different groups under study¹⁰.

The comparisons with other studies revealed that there is a great variation in FPS reflux, although most authors found a mean value similar to the one reported here²⁸⁻³⁴.

Hemodynamic characteristics and the main reflux points in the genesis of venous ulcers suggest that superficial venous system insufficiency is the most frequent cause of trophic lesions secondary to venous disease^{35,36}. Those patients that have wounds that do not heal with

clinical treatment, medication, compression or surgery of the superficial veins are candidates for valve reconstruction of the deep venous system, and the PV plays an important role in prognosis^{35,37-39}. Reflux insufficiency in infrapatellar deep veins of the microcirculation favors the appearance of trophic ulcers³⁵. Carpentier et al. performed PV valve reconstruction in 19 patients that had not responded to clinical treatment or conventional varicose vein surgery, and in 13 (68%) cases healing was complete in three months⁴⁰. According to other authors and surgeons, FPS valve reconstruction is essential for the healing of refractory lesions^{14,34}.

This study demonstrated the association between venous reflux and venous distension, as shown in Table 1, as the increase in PV diameter was followed by a greater reflux proportion, both in superficial and deep veins. In the calf, PV has a relevant role, because this is the point of convergence of the venous system at this level. Therefore, the increase in its diameter is a sign of the magnitude of venous insufficiency²⁰ (Table 1).

A recent clinical trial used PV diameter as one of its main evaluation parameters and compared compression treatment and medication in patients with chronic venous insufficiency. The authors found a decrease in PV diameter when treatment was successful, which also affected patient symptoms³⁸.

In this study, FPS reflux was found in 56 (47.45%) of the limbs, but not in 62 (52.55%). Other authors found deep venous insufficiency in 9.3% to 85.5% of their cases³³, a very large variation between the results of several studies, although most had a mean value similar to the one found in our study^{23,30-33}. Reflux was more frequent in the superficial veins, as shown by GSV in Table 6, than in the deep veins, whereas the frequency of reflux in the FPS and GSV increased as PV diameter increased, as seen in Table 1.

Sukovatykh et al. studied the hemodynamic characteristics and the main reflux points in the genesis of

venous ulcers and suggested that superficial venous system insufficiency is the most frequent cause of trophic lesions secondary to venous disease, in agreement with other studies.^{35,36} Those patients whose lesions do not heal with clinical treatment, medication, compression or surgery of the superficial veins are candidates to valve reconstruction of the deep vein systems, in which case the PV has an important role in prognosis.^{35,37,41} Sukovatykh et al. found reflux insufficiency in infrapatellar deep veins of the microcirculation, a condition that favors the appearance of trophic ulcers³⁶. Rosales et al. performed PV reconstruction in 19 patients that did not respond to clinical treatment or conventional varicose vein surgery and found that healing occurred in up to three months in 13.68% of the patients⁴². Other groups of authors and surgeons, such Labas and Ohradka or Raju and Fredericks, have, for a long time, recommended FPS valve reconstruction as an essential procedure for the healing of refractory lesions^{14,43}.

Mean PV diameter in our study was 1.14 cm, and mean diameter in the population, according to the literature, ranges from 0.5 to 0.7 cm; there is little variation of the cross-sectional diameter of veins when measured in the same position using DUS²⁰.

Salles-Cunha et al. studied the changes in FPS diameter to plan the placement of an endovascular vein valve and found values of 8.4 mm to 9.7 mm for PV with venous hypertension due to valve insufficient. They classified their results as fundamentally important for the planning of this type of treatment⁴⁴.

PV diameter also seems to affect the area of venous ulcer, as shown in Table 5, which shows that a mean increase in PV diameter is followed by a corresponding increase in the venous ulcer area, which suggests that the greater the PV diameter, the greater the ulcer size.

The analysis of sex revealed that our findings were similar to those described in the literature^{6,7,13,39}. A recent study found a proportion that is similar to the one we found

Table 1. Distribution of PV diameter according to FPS and GSV reflux in 118 limbs.

Popliteal vein diameter	Femoropopliteal segment reflux		P	Great saphenous vein reflux		P
	With	Without		With	Without	
0.60 to 0.90	7	10	0.233	12	6	0.079
0.91 to 1.20	29	37	0.163	57	8	0.001
1.21 to 1.50	16	12	0.227	24	4	0.001
1.51 to 1.80	3	3	-	5	1	-
1.81 to 2.10	1	0	-	0	1	-
Total	56	62	-	98	20	-

FPS – Femoropopliteal segment. PV – popliteal vein. GSV – great saphenous vein.

and suggested that heredity and gestations are responsible for this proportion (Table 2)³⁹.

Varicose veins progress spontaneously, and younger patients have a lower percentage of varicose veins than individuals older than 60 years. The prevalence of venous ulcer follows that trend and also increases with age in both sexes: its greatest prevalence is found around age 80 years^{40,45,46}. This study did not find patients younger than 30 years with venous ulcers, and age distribution peaked at 60 to 69 years, but mean age was 53 years. Most studies in the literature found a higher mean age, which may be explained by the longevity of their populations, as most studies have been conducted in Europe or the USA. In another study, treatment of 202 patients with the Penang venous disease in Malaysia, who formed a group of great ethnic diversity comprising, for example, Chinese, Malays and Indians in a region where socioeconomic conditions are similar to those found in the northeastern region of Brazil, mean age was 52 years⁴⁶ (Table 3).

In all the occupations found in our study, people spend long periods of time standing or under high temperatures, which contributes to the progression of venous disease, as reported in similar studies⁴⁷⁻⁴⁹. In Malaysia, the most frequent occupations among patients with varicose veins were: homemakers (43%), blue collar workers (19%) and salespeople (12%). The highest rate of venous ulcers was found among indigenous people, and 32.5% of all patients were treated, and the cause suggested by the authors in their discussion was their low body mass index and low socioeconomic status⁴⁶.

Genetic inheritance as an etiological factor of primary varicose veins is practically a consensus, but the form of gene transmission remains hypothetical. The explanation most often found is polygenic inheritance⁵⁰, which is affected by individual and environmental factors and the price that humans pay for adopting a biped position and walking on rigid floors⁵¹. Inheritance is estimated at 50%, more frequent when the mother is affected and more serious when inherited from the father⁵¹. A prospective analysis of 67 patients and their parents, in a study that included spouses and their parents as controls at a total of 402 individuals, found development of varicose veins in 90% of the cases whose parents were both affected, 25% among men and 62% among women when one of the parents was affected, and in 20% of the cases when parents did not have the disease, which confirmed the hypothesis of autosomal dominant transmission with variable penetrance⁵¹.

A study conducted in Malaysia investigated symptoms of patients that sought treatment for varicose veins, and the authors found, in decreasing order of severity, pain

in 80% of the cases, edema in 65.5%, heaviness in 53.3%, cramps in 53%, lipodermatosclerosis in 39%, superficial thrombophlebitis in 33.5%, venous ulcer in 32%, eczema in 22% and cellulitis in 12.5%⁴⁶. Their percentage of signs and symptoms was below the ones that we found, but their patients were classified as CEAP 2 to 6, whereas our study included only the clinical phase of CEAP 6 and, therefore, more advanced disease (Table 4).

A study using a questionnaire compared 288 patients with small or great FV insufficiency and 550 individuals in the general population to investigate, specifically, muscle cramps. The incidence of calf cramps was significantly greater in the group with venous insufficiency than in the general population (91% and 75%)⁵². Their rate was also greater than the one we found in this study, even if compared with the general population, and the most plausible explanation was the better muscle conditions, maybe as a result of the fact that most were farmers and walked frequently during their daily activities.

Venous ulcers are the most advanced stage of venous disease and are a reflex of chronic venous hypertension associated with inflammation. Their characteristics, particularly their surface area, are parameters to estimate severity and healing time. Most of the last venous ulcers found in this study had an area below 10 cm² and were classified as small. They accounted for 70% of all cases, followed by the 27% of the cases that were mid-sized ulcers, measuring 10 to 100 cm², and 2.5% of large ulcers, with an

Table 2. Distribution of 118 limbs according to sex in a group of patients with venous ulcer examined to investigate FPS reflux.

Sex	Reflux	No reflux	p
Women	12	16	0.227
Men	45	45	-
Total	57	61	

FPS – Femoropopliteal segment.

Table 3. Distribution of 118 limbs according to age in a group of patients with venous ulcer examined to investigate FPS reflux.

Age group	Reflux	No reflux	P
30 to 39	9	7	0.691
40 to 49	11	12	0.417
50 to 59	13	19	0.144
60 to 69	17	23	0.174
70 to 79	4	1	-
80 to 89	2	0	-
Total	56	62	-

FPS – Femoropopliteal segment.

area larger than 100 cm². These findings are similar to those reported by other authors and can be used to estimate patient prognosis, response to treatment and time necessary for healing^{41,53,54}. In the study conducted by Milic et al., venous ulcer area smaller than 20 cm² was one of the factors of a good prognosis of healing after compression treatment⁵³.

Margolis et al., however, used the parameters of an ulcer larger than 5 cm² or at least 6 months of time it was open to estimate prognosis of time it would take to heal after compression treatment⁵⁴. Chaby et al. also evaluated venous ulcer surface area and found that the larger the lesion, the worst the prognosis; however, they did not divide their sample into groups⁵⁵. Ioannou et al. evaluated 519 patients and 798 limbs with CVI, sixty with venous ulcers, classified as CEAP 5 and 6. Twenty-six patients in the latter group, that is, 43.3% of the sample, had post-thrombotic syndrome; their venous ulcers were more difficult to heal and the effect of reflux elimination in the superficial system after surgery was not clear⁵⁶.

Table 4. Distribution of number of associated symptoms in a group of 104 patients with venous ulcer.

Symptoms	Patients
1	3
2	3
3	5
4	20
5	10
6	23
7	40
Total	104

Table 5. Distribution of venous ulcer area according to femoropopliteal segment reflux and mean popliteal vein diameter in 118 lower limbs.

Venous ulcer area	Reflux (FPS)	No reflux (FPS)	P	Mean diameter (PV)
<10 cm ²	40	43	0.371	1.09
10 to 100	16	16	-	1.19
>100 cm ²	0	3	-	1.31

FPS – Femoropopliteal segment. PV – popliteal vein.

Table 6. Distribution of 118 lower limbs according to femoropopliteal segment reflux and great saphenous vein reflux in a group of 104 patients with venous ulcer.

Incompetent venous segment	Limbs with reflux
Femoropopliteal	20
Great saphenous vein	60
Femoropopliteal and great saphenous vein	38

The frequency of reflux in the superficial veins is greater when combined with deep vein reflux. Labropoulos et al. found that ulcer incidence increases when there is also extended reflux to the superficial veins, and that 47% of the patients with symptomatic post-thrombotic syndrome had superficial and deep venous insufficiency²³.

Most studies recommend surgery of the superficial system as the adequate treatment in case compression and medications fail^{57,58}; it is only in the most refractory cases that the hypothesis of procedures in the deep system are examined.

The effective contraction of the calf muscles may generate pressures greater than 300 mmHg, which promotes blood flow. To ensure the direction of flow, veins have valves that prevent reflux during this cycle of muscle contraction and relaxation⁵⁹. The PV is a component of the deep venous system, and its incompetence has been strongly associated with difficulties in the healing of venous ulcers. Studies suggested that a PV with competent valves acts as a barrier against infrapatellar deep venous reflux^{12,15}.

Mean PV diameter is relevant because the venous systems converges at this point in this level; an increase in diameter indicates the magnitude of venous insufficiency and is an important parameter of response to either clinical, surgical, conventional or endovascular treatment.

Data about sex, age, ulcer time of activity, occupation, heredity, use of contraceptive hormones and form of administration, clinical conditions, ulcer diameter, presence of reflux, history of DVT, GSV insufficiency and insufficiency of perforating veins have a particular importance in characterizing the sample under study according to demographic, socioeconomic and cultural traits, which makes it possible to establish critical analyses of the environment where patients live and make comparisons with populations with different characteristics.

Conclusions

The frequency of venous reflux in the femoropopliteal segment in patients with venous ulcer in this study was 47.45%, and patients with reflux had greater morbidity, a factor that should be included in the evaluation of their prognosis.

Mean diameter of the popliteal vein in the group under study was 1.14 cm, about twice the mean diameter in the general population, which is indicative of the magnitude of venous insufficiency. This increase results from greater retrograde pressure when standing and from dilatation of the veins that converge at this level, which is associated, in

this study, with the diameter of the corresponding venous ulcer (Table 5).

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