IMAGING ASPECTS OF COMMUNICATING VEINS IN CHRONIC VENOUS INSUFFICIENCY

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Keywords: *chronic venous insufficiency, ultrasound, phlebography, communicating veins/perforator veins,*

Abstract: *Chronic venous insufficiency (van der Molen) (1) is a clinical syndrome with different etiology, prognosis and therapeutics that is subsequent to chronic disturbances of venous circulation, especially in the lower limbs, resulting in significant changes in the interstitial space, lymphatics and skin. Chronic venous insufficiency (CVI) includes two clinical divisions almost similar, but different in terms of etiopathogenesis, therapeutics and prognosis: superficially chronic venous insufficiency representing the late stage of superficially veins insufficiency and varicose disease and chronic deep venous insufficiency, represented by the (post-thrombotic) postphlebitic syndrome. This article has been drawn up based on the PhD thesis of Dr. Ciprian Sofariu aiming at the: analysis of certain epidemiological factors relevant to the onset of the varicose disease and of the deep vein thrombosis (endogenous factors: anthropologic, anatomic and physiological, genetic, constitutional, sex, age, endocrine, pregnancy, obesity, health status and exogenous factors: physical and social); morphological analysis of some static and dynamic aspects of ultrasound, colour and spectral Doppler in the varicose disease, deep vein thrombosis (DVT) and the post-thrombotic syndrome compared with phlebography; determining the role of the two radio-imaging methods in the diagnosis of chronic venous insufficiency. This article describes the imaging aspects characteristic to the changes occurred in the perforator valves.*

Cuvinte cheie: *insuficienţa venoasă cronică, ecografie, flebografie, vene perforante*

Rezumat: *Insuficienţa venoasă cronică (van der Molen) (1) este un sindrom clinic cu etiopatogenie, prognostic şi terapeutică deosebite, ce se constituie tardiv, ca urmare a unor tulburări cronice ale circulaţiei venoase, în special la nivelul membrelor inferioare, ce antrenează modificări importante ale interstiţiului, limfaticelor şi pielii. Insuficienţa venoasă cronică include două subdiviziuni clinic aproape similare, dar deosebite din punct de vedere al etiopatogeniei, terapeuticii şi prognosticului: insuficienţa venoasă cronică suprafascială, stadiul tardiv al insuficienţei venelor superficiale şi al varicelor şi IVC subfascială reprezentată de sindromul posttrombotic. Acest material este elaborat pe baza tezei de doctorat a Dr. Ciprian Sofariu ce şi-a propus: analiza unor factori epidemiologici relevanţi în declanşarea bolii varicoase şi a trombozei venoase profunde (endogeni: antropologici, anatomofiziologici, genetici, constituţionali, sex, vârstă, endocrini, sarcină, obezitate, stare de sănătate şi exogeni: fizici şi sociali); analiza aspectelor ecografice morfologice statice şi dinamice, Doppler color şi spectral în boala varicoasă, TVP şi sindromul posttrombotic, comparativ cu cele flebografice; stabilirea rolului celor două metode radio-imagistice în diagnosticul IVC. Articolul descrie apectele imagistice caracteristice modificărilor produse la nivelul valvulelor perforante.*

Perforating veins play an important part in the hemodynamic status of the lower limbs, being a system of "locks" with two valves, ensuring a unidirectional flow, facilitated by the muscle pump, from the surface low pressure system to the deep high pressure system. Maintaining flow direction depends on the integrity of some fragile cuspids of the valve system, easily injured within the context of the pressure games, of increasing the vascular calibre, especially in case of thrombophlebitis.

Although necroptic and imaging studies (1) showed that there are approximately 80-140 communicating veins for each lower limb, only few have larger diameters and are available to ultrasound examination, being important in peripheral chronic venous insufficiency

Figure no. 1. Schematic representation of the main groups of perforator veins according to Baun (2)

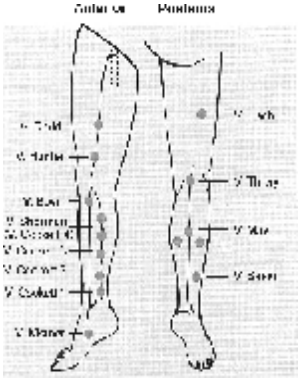

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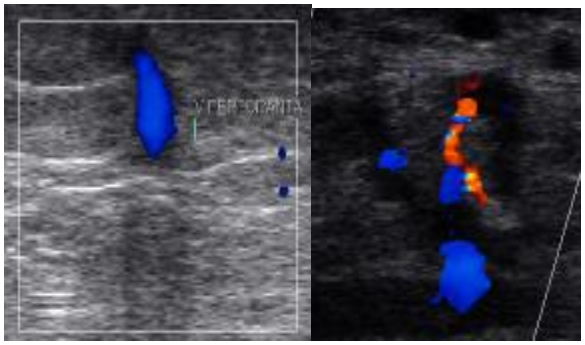
Table no. 1. Anatomical booster of the main groups of communicating veins

At hip level			
		accomplishes connections between:	
Anatomical highlights	**Name of the perforator veins**	**Superficial veins**	**Deep veins**
1/3 superior hip	Distal terminals	Safena magna	Femoral vein
Perineum	Perineal	Safena magna and the posterior branches/Giacomini vein	Uterine and ovarian veins
1/3 middle hip	Proximal terminals	Safena magna+ branches	Femoral vein
1/3 inferior hip/adductors channel	Dodd veins	Safena magna+ branches	Femoral vein
Popliteal and shank area:			
		accomplishes connections between:	
Anatomical highlights	**Name of the perforator veins**	**Superficial veins**	**Deep veins**
Internal subcondylar region	Boyd vein	Safena magna+branches of the subcondylar region	Popliteal vein or the tibial and peroneal veins
M. gastrocnemius medialis head	M. gastrocnemius medialis	Safena magna+periarticular branches	Gastrocnemial veins
Medial supramalleolar area	Cockett veins	Posterior branches of the Safena magna	Posterior tibial veins
1/3 distal to lateral shank	Peroneal veins	Anterior branches of Safena magna	Peroneal veins
Inframalleolar area	Retromalleolar and inframalleolar veins	Safena and marginal branches	Plantar veins

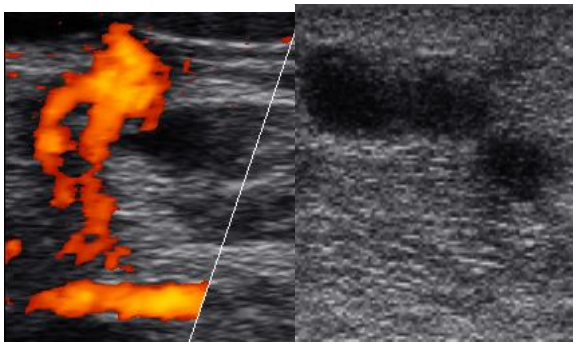
Jim Baun describes four types of the communicating veins:

Figure no. 2. I. Single connection between the superficial and the deep vein. II. A few branches link the superficial vein to the deep vein, two superficial veins and one deep vein. III. Two deep veins linked to one superficial. IV. Ascending communicating veins along the muscle compartments

I **II**



III **IV**



On routine ultrasound examination of the veins of the lower limbs, detecting the communicating veins without pathological changes is difficult. We could say that the /ultrasound display of the perforator veins should raise a question mark to the sonographer.

Calibre variations should also be correlated to other aspects: location, number, trajectory (linear, sinuous), Baun configuration, flow direction (normally, from superficial to deep), its modifications when applying the dynamic manoeuvres, body mass index, presence of pathological changes at the level of the superficial and/or deep venous system or the existence of certain clinical manifestations due to the peripheral venous system disorders.

Communicating veins between the deep and superficial system with a diameter less than 2mm, with linear unique course, and flow direction from superficial to deep, without reversing the spontaneous flow or as a result of dynamic manoeuvres, serendipitously detectable, or paying special attention to the anatomical region, where they probably can be found, with performing ultrasound technique (Power Doppler sensitive) can be considered "normal, competent" in the context of the absence of pathological changes of the superficial or/and deep venous system.

Strictly according to the calibre variations, two dimensional thresholds have been identified:

1. Below 2mm: 96% of them have been serendipitously detected, without pathological changes, the rest of 4% being associated to the onset of the varicose disease but with normal function of the own valves.
2. Between 2 and 3mm (border line), when the flow course is maintained centripetally, with shape changes in 28% of cases, and sometimes, dynamic manoeuvres, flow reversible reversing can be detected in approximately 7% of cases. This limit of 2-3 mm represents a boundary between the communicating veins with and without pathological changes.
3. Over 3mm: in a percentage of approximately 94%, these perforator veins present morpho-functional changes: sinuous course, calibre inconsistency, valve

incompetence with the reverse of the flow, initially reversible in the middle of the lumen, then totally permanent. Mention must be made of the fact that it is always associated with pathological changes of the two systems it interconnects: varicose disease, thrombophlebitis, deep venous thrombosis.

Figure no. 3. Perforator vein detected on routine ultrasound

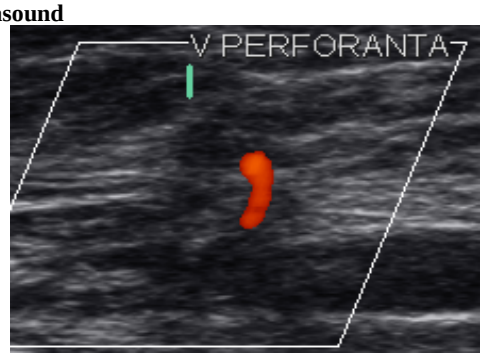


Figure no. 4. Perforator *border line* type vein (2-3 mm)

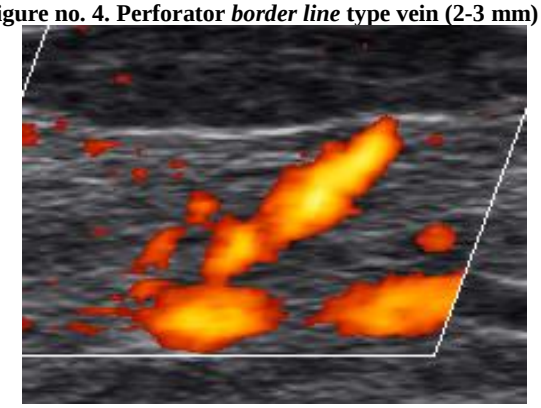
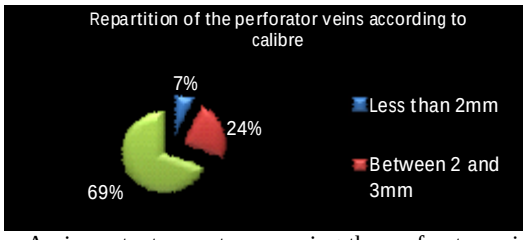


Figure no. 5. Repartition of the perforator veins according to calibre



An important aspect concerning the perforator veins is the assessment of the competence of the valve system, indirectly through the detection of the flow course on Doppler colour (colour flow) examination.

Spectral Doppler is not so easily used in establishing the flow course due to the need of permanently adapting the Doppler angle and due to the rapid change of the positivity or negativity of the waves upon small alterations in the direction of the communicating veins. It is important to notice the flow course, both spontaneously and after the application of the dynamic manoeuvres, carefully avoiding the false positive results generated by the sinuous course of the perforator veins induced by the mismatch of the US beam angle to the vascular course.

Flow reversal, which is visible on colour flow, by changing the colour, can be doubled by the spectral appearance where the change of the waves from the baseline is noticed (negativity or positivity according to the device setting)

Figure no. 6. Partial reflux (normal spectral aspect, partial reflux visible in colour flow)

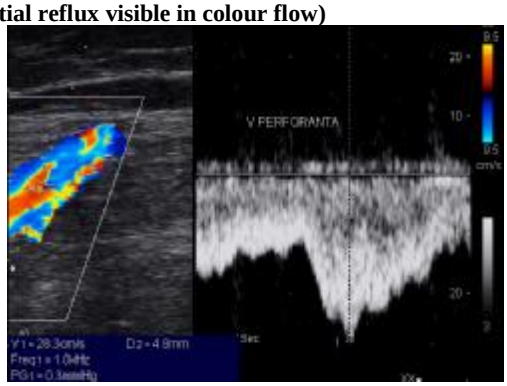
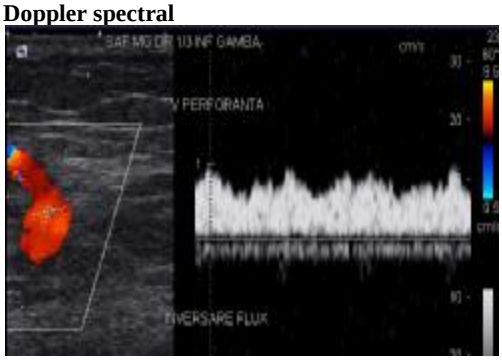
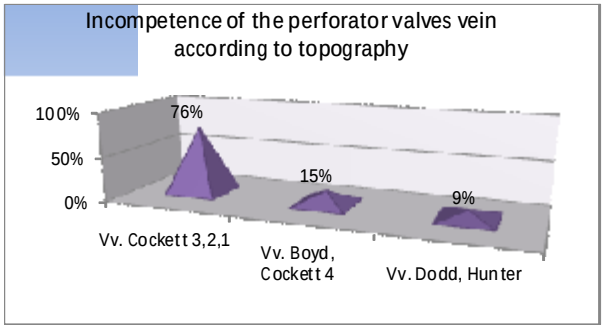


Figure no. 7. Complete reversal of the colour flow course and Doppler spectral



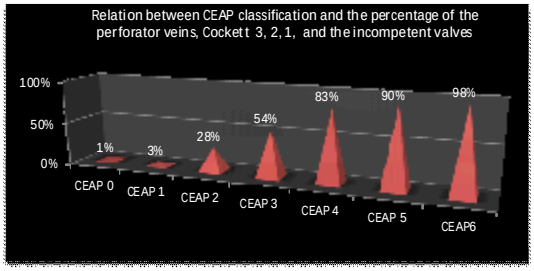
Regarding the establishment of a correlation between the perforator vein valve incompetence with veins topography, it should be mentioned that the majority of the incompetent valves belong to the Cockett perforator 3, 2 and 1 veins located at approximately 15-20cm internal supramalleolarly in 76% of cases. Lower percentages were recorded in the third upper area of the shank 15% (Boyd and Cockett 4) and in the half lower area of the hips 9% (Dodd and Hunter).

Figure no. 8. Incompetence of the perforator valves veins according to topography



It can also be established the existence of a correlation between the incompetence of the valves of the perforator veins and the degree of suffering of the patients with varicose disease, expressed according to the clinical classification of CEAP (3) in the sense of increasing the grading proportionally with the sufferance of the perforator valves. As it can be seen, the severity of the varicose disease is closely related to the damage of the valves of the perforator veins, the number of subjects with incompetent perforator veins being higher in the 4,5,6th, stages of the clinical classification.

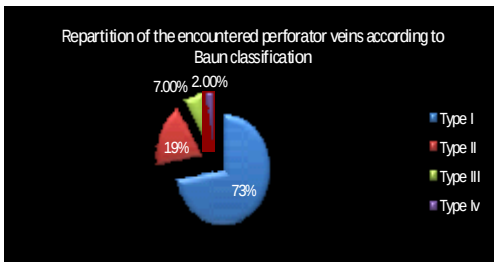
Figure no. 9. Relation between the CEAP classification and the percentage of the perforator veins, Cocket 3, 2, 1 and the incompetent valves



Stuart and collaborators (3,4) presented a study in which they established the existence of a correlation between the incompetence of the perforator veins and the existence of the reflux at the level of the superficial venous system.

Perforator veins on phlebography images stand out much easier than on the ultrasound examination, where the device performance, the time set for the examination, the sonographer and his versatility influence their detection. Perforator veins are easier to quantify in terms of morphology, number and Baun classification, but the direction of flow, velocimetrics and valves incompetence are much easier to quantify on ultrasound. Due to a better view of the morphological aspects, Baun classification suffers small changes, such as increasing the identification of the double perforator veins, type II and III by some percentages as against those identified on ultrasound.

Figure no. 10. Repartition of the perforator veins according to Baun classification



Perforator veins belonging to the peroneal veins similar to Cockett and Boyd veins, branches of the posterior tibial veins.

Figure no. 11. Phlebographic aspect of the perforator veins belonging to the peroneal veins

Similarly to Boyd perforator veins that link the branches of Safena magna vein from the internal subcondylar area with the popliteal vein, tibial and peroneal veins, there is a relatively constant group of veins, most of them double (Baun type II and III) placed posteriorly-externally that link the branches of Safena parva or the communicating veins between both safena veins and the peronial veins.

In the same manner, other three similar groups of perforator veins are identified, placed at the junction between the 1/3 superior and 1/3 middle, in the 1/3 middle and at the junction between 1/3 middle and 1/3 inferior, somehow similar to Cockett veins – 4,3 and 2 laterally disposed. These perforator veins open in extreme situations: advanced varicose disease, deep vein thrombosis. The same morphological aspects are easier to be detected on phlebography, slightly changing the location of the less accessible perforator veins, such as those placed on the posterior part of the shank, to which the sonographer pays less attention.

Figure no. 12. Repartition of the anterior perforator veins according to localisation: ultrasound

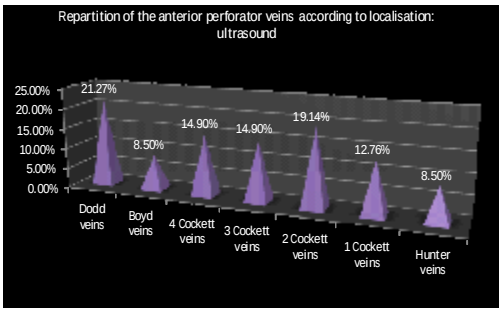
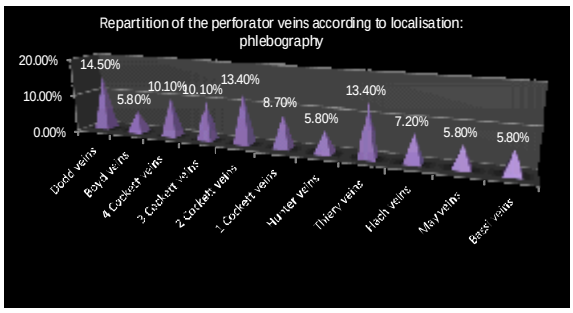


Figure no. 13. Repartition of the perforator veins according to localisation: phlebography

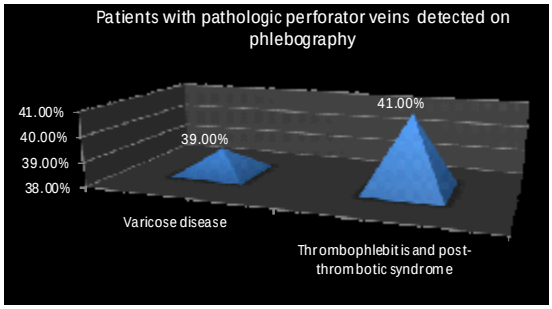


Comparing the two methods of ultrasound and phlebographic examination, we can state that the identification of the perforator veins of the Cockett and Boyd group, has been made in similar percentages.

Although the performances of phlebography are higher than those of ultrasound regarding the detection of the perforator veins with a location slightly difficult for the ultrasound approach, we must mention that many of the perforator veins detected on phlebography are not altered pathologically.

Considering that vessel diameter is a valid criterion in terms of phlebography regarding the pathological changes of the perforating veins, although perforating veins were identified in almost all the patients with phlebography, in the study batch, those pathological were identified in approximately 39% of the subjects with varicose disease and in 41% of the patients who had a history of superficial or deep thrombophlebitis, without a significant difference between genders.

Figure no. 14. Distribution of patients with pathologic perforator veins detected on phlebography



The assessment of the flow direction can also be made on phlebography, observing the progression of the contrast substance, but velocimetry, the answer to the dynamic manoeuvres, the assessment of the reflux at the level of valves are difficult to evaluate in real time, requiring a higher dose of irradiation, useless in the context of the ultrasound possibilities of assessing these parameters.

Conclusions:

Although phlebography provides additional morphological information to ultrasound, identifying every small perforating vein, ultrasound proves its superiority in evaluating the incompetence of these vessels spontaneously and after applying the dynamic manoeuvres, flow direction, velocimetry, reflux at valves level.

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