VENOUS RETURN REVIEW

The measurement of venous pressure by Doppler: is it a hemodynamic evaluation ?

PL Antignani[1], G Peruzzi[2], T Spina[3]

[1]Director, Vascular centre, Nuova Villa Claudia, Rome, Italy. President of the International Union of Angiology.

[2]Casa Di Cura Villa Donatello Spa, Firenze, Italy

[3]Ambulatorio Vascolab, Via Provinciale, 22 – Cariati (Cs), Italy

submitted: Jun 6, 2021, accepted: Jul 21, 2021, EPub Ahead of Print: Jul 26, 2021
Conflict of interest: None

DOI: 10.24019/jtavr.114 - Corresponding author:Prof. Pier Luigi Antignani, antignanipl@gmail.com

Abstract

Since 1980 using the Doppler method, planned by Bartolo, we have studied several patients by means of the measurement of venous pressures, both in orthostatism and in clinostatism.

In a normal subject, in orthostatism the value of average pressure is 60 mmHg in the posterior tibial vein, and 60 mmHg in the long saphenous vein. When there are varicose veins, the average pressure is 90 and 96 mmHg respectively in the deep veins and in the superficial ones.

In the case of post-thrombotic syndrome, the average values are 101 and 102 mmHg in the deep and superficial veins, respectively. In clinostatism, the normal values are under 20 mmHg and in subjects with vein thrombosis the value increase to 30 mmHg and more.

After more than 30 years we discuss the reliability of the method, the hemodynamic basis and its clinical application in phlebological practice.

Keywords chronic venous disease, Doppler method, superficial venous system, deep venous system, venous hemodynamics

Introduction

In 1949, Hojensgard and Sturup[1] found identical orthostatic and hydrostatic pressure in different subjects and declared that a venous hypertensive condition can be measured only during movement in subjects with varices.

The patients may be divided in primary or post-thrombotic according to the modification of the dynamic pressures after the occlusion of the superficial circulation by means of a tourniquet; in the case of essential varices, the occlusion of the superficial circulation normalizes the pressure value in the deep system at the end of the exercise and there is a longer recovery time while this improvement does not occur in the deep system in post-thrombotic varices.

Venous pressure can be measured either directly or indirectly. A direct measurement is obtained by the vein puncture with a needle connected either to a water column (whose height can be measured directly, expressing the pressure in cmH_2O) or to an electromanometer.

Indirect measurement is mentioned by Sturup and Hojensgard themselves. They define it as "the external pressure necessary to cause the collapse of a superficial vein or the lowest pressure preventing the filling of a previously emptied vein" and they mention some authors who used it.

Measurement of venous pressure using the mercury manometer by a method similar to the one used in the arterial field was therefore an attempt based on a rough inspective criterion and could be carried out only with physical means adequate to the noninvasive measurement of the flow in the veins. This gap was filled by the introduction of the Doppler ultrasound apparatus.

The indirect measurement of the venous pressure of the limbs in this manner was proposed at nearly the same time by Bartolo[2] and Gayliss[3] in 1975.

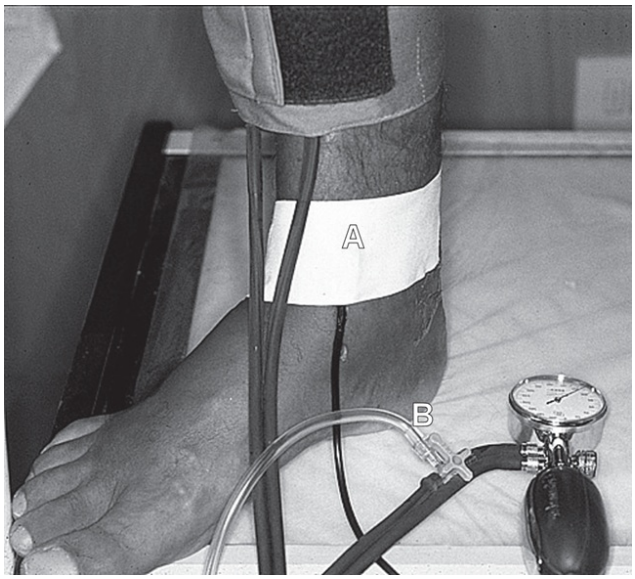

Figure 1 - The Doppler venous pressure measurement on a right lower limb in a patient affected by chronic venous disease. The placement of the pneumatic cuff and of a flat probe of 8 MHz by plaster is visible (A). The catheter (B) was used for the previous measurement of the invasive pressure as validation of the method.

Tensive measurements

Using Bartolo's technique[4-9] venous pressure is measured by applying the arm-band of a common sphygmomanometer over the limb segment to be examined while the Doppler probe at 8 MHz is placed below it. The correct positioning of the probe on the vein can be ascertained by artificially sending some pulses through the compression of the segment below the probe itself (Fig. 1).

The cuff is inflated until a counterpressure slightly superior to the one presumed is obtained and after deflated. At a certain point it is possible to hear a "wind noise" which decreases until it is exhausted (Fig. 2). The pressure level at which the noise occurs, indicates the moment in which the venous flow is restored since its pressure has become lower than the one existing in the cuff, similar to what happens in the measurement of arterial pressure which we perform daily in all our patients.

In order to express repeatable and reliable results it is necessary to eliminate all possible mistakes.

It is important for the operator to have considerable experience in order to carry out measurements as precisely as possible.

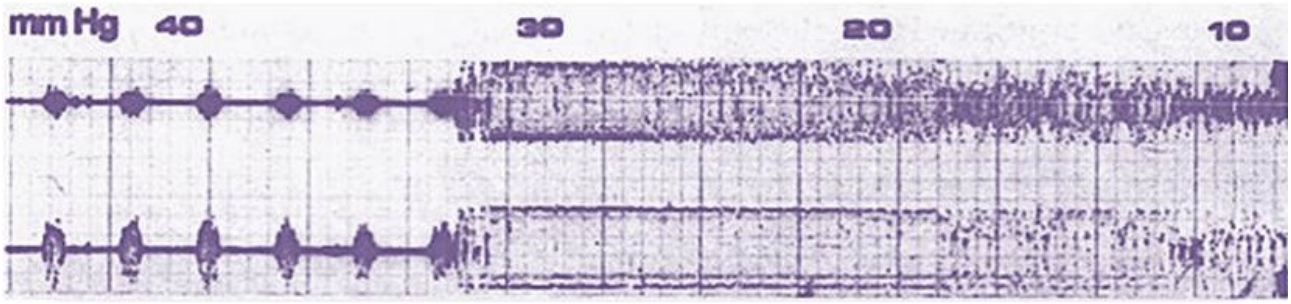

Figure 2 - Phonoangiograph connected to the Doppler instrument. The onset of the "wind noise", near to 33 mmHg, is recorded. The noise corresponds to the venous outflow previously stopped by the pneumatic cuff and indicates the venous pressure value.

The applied counterpressure should not exceed 120 mmHg in orthostatism and 60 mmHg in clinostatism. Higher counterpressure values would probably give higher results due to venous hypertonic reactivity.

The measurements should be carried out as quickly as possible since venous pressure is inclined to increase over time. This is due to the fact that the area above the cuff receives arterial blood flow during the compression and therefore the venous pressure will increase proportionately due to the trapping of that blood.

The pressure values noticed in the measurements made at dose intervals, become stable on the third, fourth and fifth measurements, being higher on the first and second. This is caused by the progressive loss of the wall's reactive tonic venous capacity as the hypertensive strain proceeds. The third measurement and the successive ones are therefore the nearest to the tensive mark, the reactive capacity of the venous district being exhausted.

The measurements should moreover be done with the cuff in the closest possible position to the probe. Otherwise the obtained values will be incorrectly low. In fact, when the area between the probe and the cuff is reduced, the venous

hypertonic reaction will be more immediate, while since the overall compliance is higher in the case of a larger area, the hemodynamic effect can be significantly mitigated and the "wind noise" can be reduced.

Measurements can be carried out either at the ankle on the tibial posterior vein behind the internal malleolus, or on the long saphenous vein in front of it or on the short saphenous vein behind the external malleolus both in clinostatism and in orthostatism. Upper limb measurements can be done on the humeral, radial, ulnar, cephalic or basilic veins in clinostatic position.

Currently the measurement can be effected by the echo Duplex scanner with the same method.

Results

In normal subjects, Doppler venous pressure values in orthostatism at the ankle are slightly lower than 60 mmHg. In clinostatism the tensive values vary from 0 to 20 mmHg. Values are considerably higher in subjects suffering from chronic venous diseases of the lower limbs (90 mmHg in the deep system and 96 mmHg in the saphenous system).

In post-thrombotic syndrome both superficial and deep venous pressure reach the highest possible values (102 and 101 mmHg respectively). This explains the peculiar pains of subjects suffering from this condition. In this syndrome there could be at the beginning deep hypertension that is more evident than the superficial one (up to 130-140 mmHg).

It must be noted that in the opposite limb to the thrombotic one both superficial and deep hypertension are seen. This is probably due either to the fact that these subjects lean on the normal limb with consequent phlebostasis, or that even in these limbs an unknown venous thrombosis has occurred.

In cases of lymphoedema it is interesting to note that both the superficial and deep circulation have pressure values above normal (71 and 72 mmHg respectively) thus confirming the damage to the venous system arising in lymphatic disease.

In the upper limb in cases of thrombosis of the upper vena cava it is possible to quote in clinostatism average values equal to 78 mmHg on both arms, while in cases of axillary thrombosis the average values on the humeral vein are equal to 39 mmHg.

The invasive measurement of the venous pressures has been more often carried out in dynamic than in static conditions as tiptoeing. Considering the time necessary for cuff insufflation and desufflation it is quite difficult to follow the pressure variations on the leg, second by second, with the Doppler method as they appear in the dynamic experiments so far carried out using the invasive measurement method.

A possibility is to use a dynamic test on the ankle consisting in the squeezing of the calf either with or without tourniquets and the immediate measurement of the pressure variations at the ankle. The results obtained in orthostatism confirm the data in the literature: maximum hypotension just after calf squeezing in normal subjects, a more reduced hypotension in varicose subjects and either a poor hypotensive effect or even slight hypertension in case of post-thrombotic syndrome[10].

Validation of the method

Considering the difference between the Doppler values of venous pressure and the ones quoted in the literature and obtained by invasive methods, it has been necessary to perform simultaneous measurements of venous pressures, using the two methods. The comparison between invasive and Doppler values of venous pressure[4-6] shows that the pressure indicated by the sphygmomanometer when cuff deflation once more allows the passage of the venous flow, is the one really existing in the vein; the differences from data in the current literature (mainly consisting in the fact that in orthostatism all authors find equal venous pressures in normal and in phlebopathic subjects in static conditions, while the Doppler method reveals hypertension in phlebopathic subjects and hypotension in normal ones) is not due to a technical mistake but to the presence of the cuff. In fact the use of the cuff is the only experimental condition which makes the noninvasive experiment different from the invasive one; the venous area under the cuff shows two different reactions to the obstacle created by the hypertension of the cuff: hypotension in the case of normal venous compliance with a drainage operated by the cuff and reactive atony of the upper venous circulation, and hypertension in the case of increased reactivity either reflux or reduced vascular lumen in the case of phlebopathy.

So, the dynamic venous response caused by the cuff, indicates much finer pathophysiological implications than the simple invasive measurement in static conditions and can be considered as a very useful separator between normal and pathologic subjects even before possible functional tests.

Other applications

The modern hemodynamic evaluation of chronic venous disease of the lower limbs is mainly based on duplex ultrasound (DUS) examination. The majority of the authors accept the invasive venous pressure measurements which furnish hydrostatic values but do not trust in the results obtained by Doppler method, as they are influenced by many different anatomical, functional, biological, mechanical and/or environmental factors. These factors of variation cannot be completely investigated and analyzed. For this reason, the values resulting from Doppler method should be better defined as venous pressure index (VPI).

The emerging data and the acquired experience clearly demonstrated that the VPI measurements could give useful information concerning the severity and pathophysiology of chronic venous disease, and several therapeutic implications were noted[11-13].

In cases affected with early superficial venous disease, with initial reflux and limited varicose veins, the VPI measurement can represent a useful parameter for the choice of minimally invasive procedures and for monitoring the disease progression while patients are subjected to conservative treatments

A recent work[11], performed in orthostatism on more than 1044 limbs, studied the mean values of the VPI, in limbs with or without pathological reflux on greater saphenous vein (GSV) and on smaller saphenous vein (SSV). In the GSV, the highest frequency of VPI peak corresponds to 60 mmHg in the limbs with competent GSV, while in the limbs with incompetent GSV the peak is comprised between 90 and 100 mmHg. In the SSV, the higher frequency of VPI peak in the limbs with competent SSV corresponds to 40 mmHg, while in only three limbs with competent SSV the VPI is > 70 mm.

In the posterior tibial vein (PTV), two peaks of VPI are visible. The first one corresponding to a maximum of 60 mmHg in limbs with competent GSV and the second corresponding to a maximum of 80 mmHg in limbs with incompetent GSV.

On the bases of the VPI results it is possible to decide where and how to extend superficial and/ or deep veins surgery and/or endovascular treatments, as endovenous laser and sclerotherapy of superficial venous insufficiency of the lower limbs, for the patient's follow-up and for a more precise selection of the class of compression stockings[11-13], which makes the patients more compliant than in the past.

The VPI does not always correspond to the clinical class of the disease. Therefore, it can be affirmed that such a parameter can easily make it possible to calculate the mean counter pressure necessary in every single limb and, consequently, to choose the more proper class of compression of elastic stockings more than by a simple clinical criterion.

References

1) Hojensgard IC, Sturup H. Venous pressure in primary and post-thrombotic varicose veins. Acta Chir Scand 1950;99:133.

2) Gayliss H. Some observations on peripheral venous pressure using a noninvasive technique: A preliminary report. Brit J Surg 1975;62:259.

3) Bartolo M. Phlebodopplertensiometry, a non invasive method for measuring venous pressure. Folia Angiol. 1975;25:199-203.

4) Bartolo M, Antignani PL, Di Folca A, Pittorino L. On some experimental conditions possibly influencing the correct measurement of venous pressure by Doppler method. G Ital Cardiol. 1982;12(5):384-7.

5) Bartolo M, Nicosia PM, Antignani PL, Raffi S, Ricci S, Marchetti M, Pittorino L. Noninvasive venous pressure measurements in different venous diseases. A new case collection. Angiology. 1983;34(11):717-23.

6) Bartolo M, Antignani PL, Di Folca A, Pittorino L, Todini AR. Measuring venous pressure with the Doppler technique: standardization of the method. Phlebologie 1984;37(1):97-101.

7) Bartolo M, Antignani PL, Nicosia PM, Raffi S, Ricci S, Pittorino L, Marchetti M. Measuring venous pressure with the Doppler technique: statistical data. Phlebologie 1984;37(1):103-8.

8) Bartolo M, Antignani PL, Nicosia PM, Raffi S. Clinical-instrumental relationships in post-phlebitic syndrome. Angiology. 1985;36(1):53-7.

9) Bartolo M, Antignani PL, Nicosia PM, Todini AR. Noninvasive venous pressure measurement and its validation. Int. Angiol. 1988;7:182-9.

10) Antignani PL, Paiella ML. Venous return: hemodynamics and physiopathology. Clin Ter. 1991; 136(2):137-43.

11) Spina T, Ferlaino E, Pontello D, Corcos L. The value of Doppler venous pressure index in chronic venous disease of the lower limbs. J Curr Surg. 2015;5(4):188-198.

12) Spina T, Corcos L, Peruzzi G, Baldelli G, De Anna D. The value of Doppler venous pressure index in the diagnosis of chronic venous insufficiency of the lower limbs. Int. Angiol. 2009;28(Suppl.1 4):92.

13) Corcos L, Pontello D, Spina T. Elastic compression treatment of chronic superficial venous insufficiency of the lower limbs based on Doppler venous pressure index measurements. Veins & Lymphatics. 2015;4(2230):2-6.