Lorenzo TESSARI, MD
Fondazione Glauco Bassi
Trieste, ITALY

Massimo CAPPELLI, MD
Studio Flebologico
Florence, ITALY

The study of the saphenofemoral junction to understand the distribution of refluxes in chronic venous disease

by L. Tessari and M. Cappelli, Italy

Some of the techniques currently in use for the treatment of the varices of the lower extremities were introduced at the beginning of the 20th century: the Narath technique in 1904 (multiple stab incisions phlebectomy), the Keller technique in 1905 (invaginated stripping on thread), the Mayo technique in 1906 (external stripping), and the Babcock technique in 1907 (internal stripping).[1]

Before any decision can be made regarding the appropriate therapeutic technique for a varicose patient, it is necessary to define how a specific area (for instance, the saphenofemoral complex) should be assessed in the patient. We are going to consider two different aspects: first, how to study an incontinent segment, and second, how to study the saphenofemoral complex (on the basis of the general criteria described for an incontinent segment). Valvular continence must be studied in the orthostatic position so as to develop a transvalvular retrograde gradient (opposite to the orientation of valvular planes). Retrograde gradients are studied in two different ways: (i) a high pressure test, such as the Valsalva test; and (ii) a gravitational test, which exploits the weight of the hematic column once it has been mobilized. Analysis of 1294 patients with incontinent great saphenous vein crosses (saphenofemoral complexes) revealed complete incontinence of the saphenofemoral junction in only 55% of cases. In 6% of cases, a dissociation pattern was noted. Using the same criteria, the proximal femoral valve (ie, the valve in the common femoral vein located above the saphenofemoral junction) was also studied. This turned out to be continent in the saphenofemoral junction and in the saphenous vein arch in 58.4% of complete incontinence cases. In cases of continence of the upper femoral valve, the saphenous trunks (measured at the mid thigh area) mostly exhibit a diameter that is less than 7 mm.

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Address for correspondence: Lorenzo Tessari, Localité Broglie 8 F, 37019 Peschiera du Garda (VR), Italy
(e-mail: lorenzo.tessari@libero.it)

In the first years of the 21st century, several new techniques for varicose vein treatment have also been developed, both in the surgical field (hemodynamic conservative surgery according to the Conservative Hemodynamic treatment of Incompetent Varicose veins in Ambulatory patients [CHIVA] strategy) and in the sclerotherapy area. The latter has recently been gaining great success, thanks to echographic techniques and the use of foam.

At present, the most commonly used techniques for treatment of the saphenous varices are those involving endovascular obliteration (laser, radiofrequency, and sclerosant foam with either a long or short catheter). These techniques have in common the inability to completely occlude the saphenous junction properly, and they therefore expose the patient to a risk of possible relapse, traditional sclerotherapy with liquid being a notable example. This is what happens whenever the surgical disconnection of the saphenofemoral junction is not performed completely flush on the femoral vein. The remaining stump can be the cause of a possible evolution of the varicose disease. On the other hand, it must be pointed out that many surgical procedures involving the saphenofemoral junction do not show any evolution signs, even if they have not been correctly performed.

These differences can be explained by the fact that endovascular procedures as well as surgery are frequently performed without any preventive hemodynamic analysis, so the same therapeutic plan is

SELECTED ABBREVIATIONS AND ACRONYMS	
CHIVA	Conservative Hemodynamic treatment of Incompetent Varicose veins in Ambulatory patients (French acronym)
C/R (test)	compression release (test)

applied in different hemodynamic conditions, resulting in different long-term outcomes. The often animated discussion regarding how to determine the best therapeutic technique has resulted in a series of publications about personalized technological approaches.

Unfortunately, these studies have often not been supported by accurate color-duplex ultrasound research of valvular functions and reflux dynamics, which could have otherwise helped to plan a more conservative and personalized therapeutic strategy. A personalized therapy should be based on an accurate color-duplex ultrasound analysis of the patient's varicose situation; this assessment leads to a morphological and, in particular, hemodynamic map, which represents the basic element for defining the therapeutic plan.

Before any decision can be made regarding the appropriate therapeutic technique to use, it is necessary to define how a specific area (eg, the saphenofemoral complex) should be studied in a varicose patient. We are going to consider two different aspects: (i) how to study an incontinent segment; and (ii) how to study the saphenofemoral complex according to the general criteria listed in point (i).

Study of an incontinent segment

Valvular continence must be studied with the subject in the orthostatic position, to develop a transvalvular retrograde gradient (opposite to the orientation of valvular planes). Retrograde gradients are of two different types; either that with a high pressure test, such as the Valsalva test, or that with a gravitational test, which exploits the weight of the hematic column once it has been mobilized. The mobilization of the column may occur in a static way through the compression/release (C/R) test (static test) or in a dynamic manner through activation of the muscular pump using any of the following: (i) Parana test; (ii) Oscillation test; (iii) Lifting on Tiptoes test; and (iv) Toes Dorsiflexion test.

◆ *High pressure gradient (Valsalva maneuver)*

The high pressure charge developed during the Valsalva maneuver is transmitted in a distal way independent of the continence of the proximal valvular planes. This is possible thanks to the closure inertia of valvular planes themselves, which permits the passage of the pressure wave. Its propagation speed is definitively superior to the speed of the hematic flux, as is clearly shown in the arterial system. We can see that the Valsalva test always determines distal transmission of the pressure wave. When valvular incontinence among different compartments is present (eg, between the deep and the superficial nets), the pressure wave is associated with the appearance of transcompartmental reflux. The passages among compartments (between the deep and superficial nets and between the saphenous system and its secondary ramifications), which are incontinent with the Valsalva test, are called points of reflux.

The evaluation of the correct execution of the Valsalva test is shown by the appearance of an anterograde flux, that is, the restarting of the flux as soon as the maneuver is completed. This shows that the hypertensive charge (ie, the blocking of anterograde physiologic flux) has been properly performed.

It is essential to highlight here that transcompartmental reflux assessment can only be performed if at the moment of application of a retrograde gradient, a re-entry system toward a compartment with lower pressure is present (which could be the deep venous system too), and the lower pressure in the "recipient" system is possible thanks to the closure of its valvular planes (dynamic subdivision of the pressure column).

The above statement can be tested in every patient. Closure through digital compression of the reflux re-entry, eg, the saphenous trunk, brings about the disappearance of the reflux in many tests, mostly the gravitational ones.[2]

◆ *Gravitational gradient*

It must be underlined that dynamic tests, through the activation of muscle-joint pumps, will mobilize much more blood at a deeper level than the C/R test, particularly in big dimension calves. We will therefore have a larger subdivision of the deep hydrostatic column through the closure of the valvular planes, with a consequent decrease in pressure, and consequently there will be the development of a much higher re-entry gradient (in the case of incontinence of the superficial net) than the one developed in the C/R test. Hence, in order to detect reflux, the dynamic tests will be much more effective than the C/R test.[3]

Gravitational tests will point out valvular incontinence in a zone distal to the position of the Doppler sample. They will not give any information on the functioning of the proximal valvular plane. Thus one must position the Doppler sample on the proximal side of the valve that is to be studied (eg, on the femoral side if we are going to analyze the functioning of the terminal saphenous valve).[4]

We can therefore state that the gravitational tests point out valvular incontinence in general, while a positive Valsalva test shows how this incontinence is mostly associated with points of reflux, which are in fact the incontinent compartment passages. Furthermore, it should be remembered that the incontinence of the venous axes is not always associated with points of reflux, in which case there will be negative Valsalva refluxes. As a consequence of these findings, it is argued that the multiple tests we currently use aimed at the elicitation of the reflux cannot be used indifferently in order to establish a diagnosis of valvular incontinence. Some valves show either commissural or complete incontinence during the Valsalva maneuver, but they turn out to be continent if exposed to a transvalvular gradient of the gravitational type.

The observation of this different valvular behavior during the execution of different tests can indicate a partial incontinence of valvular planes. These valves may as a result be continent to normal gravitational gradients caused by movement, while they "leak" under the high-pressure gradients developed with the Valsalva maneuver. These valves are thus not completely incontinent, and they have a high probability of recovery with reduction of the diameter of the venous axis through targeted surgical interventions on saphenous collaterals.[5]

Study of the saphenofemoral complex

It must be pointed out that the saphenofemoral junction is just a part of the so-called "saphenofemoral complex." The hemodynamics of this region are both physiologically and pathologically influenced by other structures. By saphenofemoral complex we mean:

- ◆ The saphenous arch (saphenofemoral cross with its two valves—the terminal valve and the preterminal valve, differently positioned). The saphenofemoral junction is part of the cross. It represents the passage between the great saphenous vein and the common femoral vein.
- ◆ The femoral valve proximal to (above) the saphenofemoral junction. This valve may not be present in 20% to 24% of patients.[6,7]
- ◆ The femoral valve distal to (under) the saphenofemoral junction.
- ◆ The upper tributaries of the saphenous arch, which in a variable way drain the superficial blood from the lower half of the abdomen. In fact, physiologically, a descending flow toward the arch can be observed. The physiological direction of flux is stated by the orientation of valvular planes.[8]

The hemodynamic study of the saphenofemoral complex consists in the positioning of the Doppler sample above and below the valve to be studied and in the application of all the aforementioned investigative methods. All these tests should point out valvular incontinence in the various parts of the complex. In this way, the hemodynamics of the region can be exactly described. The purpose of these tests is to determine a targeted therapeutic approach, which may help to avoid either incomplete or useless radical surgery, which can in fact accelerate the evolution of the varicose disease, commonly called "relapse." The study of the hemodynamics of the saphenofemoral complex must determine:

- ◆ The presence of points of reflux represented not only by the incontinence of the saphenofemoral junction but also by the connection that some pelvic points of reflux have with the great saphenous vein through the arch tributaries. In such cases, we will find arch tributaries that show a Valsalva positive reflux. The exact position of pelvic shunts must also be pointed out on the map of the leg.
- ◆ The incontinence/continence state of the terminal valve—that is, the valve situated in the area of the saphenofemoral junction. This can vary; we may have: (i) complete continence both in the Valsalva and dynamic tests performed with the Doppler sample positioned on the femoral side of the valve. In this case, both tests will be negative; (ii) complete incontinence, when both tests are positive; or (iii) dissociated findings with a leaking terminal valve under a high pressure charge, but a resisting terminal valve when gravitational gradients are applied. In this case, we have a positive Valsalva test and a negative gravitational test, particularly when a dynamic test is applied.
- ◆ The extension of the incontinence, ie, whether the reflux is limited to the preterminal, terminal or femoral valve. The study of either the continence or the incontinence/absence of the proximal femoral valve is performed by positioning the Doppler sample under the inguinal ligament. The probe must be directed from the groin upward in order to be in a proximal position with respect to the femoral valve and for subsequent application of a combination of the two maneuvers: the Valsalva and dynamic tests.[9] The incontinence extension will condition different pressure columns, with a consequent difference in the reflux hydrodynamic energy; indeed pressure is one of the energy components, together with the retrograde volume (energy = pressure × volume). The hydrodynamic energy, together with parietal factors, determines the vessel diameter. In fact there is a correlation between the incontinence extension and the saphenous vein diameter.[9]
- ◆ The level at which the upper arch tributaries drain toward the saphenofemoral junction. This level has been defined as the "geometrical discharge height of the upper arch tributaries." The disconnection of tributaries at a high geometrical height could cause the formation of a collateral circle that is vicarious because of the obstruction (iatrogenic-surgical), and this could be the source of retrograde flow either after crossectomy or after stripping-crossectomy. In such cases, the reflux is not associated with points of reflux, as is often shown in maps referring to patients operated on with excessively ablative methods. In fact, in these tributaries, the pressure components are represented not only by the residual venular pressure, but also by a high hydrostatic column. By contrast, the hydrostatic column is very low in the tributaries that are located at low geometrical height. The evolution of these collateral circles can cause cavernomas ("neovascularization"), which represent the re-entry of the relapse itself. These are negative Valsalva cavernomas. In subsequent years, these areas can become reflux points from the common femoral vein, and they can therefore become Valsalva positive reflux points. Valsalva positive reflux points can also be those cavernomas that originate from tributary disconnection from a pelvic shunt.

As a consequence of the aforementioned speculations and findings, it could be argued that the study of inflow level of the tributaries may condition the choice between tie/no tie of these arch tributaries and, in the case of their conservation, it will be of importance to decide where to let them drain—either in the common femoral vein or in the saphenous vein.

In an analysis of 1294 patients with incontinent great saphenous vein crosses (saphenofemoral complexes), complete incontinence of the saphenofemoral junction was noticed in only 55% of cases.[9] In 6% of cases, a dissociation pattern (see above) was noted. Using the same criteria, the proximal femoral valve (ie, the valve in the common femoral vein located above the saphenofemoral junction) was also studied. In 58.4% of complete incontinence cases, it was found to be continent in the saphenofemoral junction and the saphenous vein arch. In most cases of continence of the upper femoral valve, the saphenous trunks (measured at the mid thigh area) exhibit a diameter that is lower than 7 mm.[9]

These observations outline some important considerations: first, 42% of incontinence in the great saphenous vein with incontinence of the saphenofemoral junction is associated with the absence of incontinence of the femoral valve located above the saphenofemoral junction. In such cases, the hydrostatic column is of relevance, and a saphenofemoral surgical disconnection (eg, crossectomy or crossotomy) would be appropriate. Second, 58% of incontinence of the great saphenous vein with incontinence of the saphenofemoral junction is associated with continence of the proximal femoral valve. In these cases, where the hydrostatic femoral column is low, any of the endovenous procedures can be recommended when a "demolishing" operation is preferred (chosen?). Last, 45% of the generically termed "cross incontinence" in the great saphenous vein is in reality associated with continence of the terminal saphenous valve. In these cases, the therapeutic gold standard is treatment of pelvic reflux and/or suppression of incontinent peripheral tributaries (first time CHIVA 2), and surgical treatment of the cross would not be recommended. Endovenous ablative treatments could be indicated in cases where the terminal valve of the great saphenous vein is continent, although we would like to highlight the ethical problem regarding the possible demolition of these saphenous veins, which have a diameter that is normally less than 6 mm. Hence, either disconnection or sclerotherapy procedures on the incontinent tributaries can be performed, without any treatment of the saphenous trunk.[10] ❒

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ÉTUDE DE LA JONCTION SAPHÉNOFÉMORALE POUR COMPRENDRE LA DISTRIBUTION DES REFLUX DANS LA MALADIE VEINEUSE CHRONIQUE

Avant de prendre une décision concernant le traitement adéquat pour un patient variqueux, il est nécessaire de définir comment une aire spécifique (par exemple le complexe saphénofémoral) peut être évaluée chez le patient. Nous allons envisager deux aspects différents : d'abord, comment étudier un segment incontinent, ensuite, comment observer le complexe saphénofémoral, en se fondant sur les critères généraux décrits pour un segment incontinent. La continence valvulaire doit être étudiée en orthostatisme de façon à développer un gradient transvalvulaire rétrograde (opposé à l'orientation du plan valvulaire). Le gradient rétrograde est étudié de deux façons différentes : 1) un test de haute pression, tel que le test de Valsalva ; et 2) un test de gravitation, qui exploite le poids de la colonne sanguine une fois qu'elle a été mobilisée. L'analyse de 1294 patients ayant une incontinence de la crosse de la grande veine saphène (complexe saphénofémoral) n'a révélé l'incontinence complète de la jonction saphénofémorale que dans seulement 55 % des cas. Une dissociation n'était notée que dans 6 % des cas. La valvule fémorale proximale a aussi été étudiée en utilisant les mêmes critères (par ex. la valvule de la veine fémorale commune située au-dessus de la jonction saphénofémorale). Elle s'est avérée être continente à la jonction saphénofémorale et au niveau de la voûte de la veine saphène dans 58,4 % des cas d'incontinence complète. Lorsque la valvule fémorale supérieure est continente, les troncs saphènes (mesurés au milieu de la cuisse) présentent un diamètre inférieur à 7 mm.