# Haemodynamic surgery for varicose veins: rationale, and anatomic and haemodynamic basis

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## Abstract

The treatment of varicose veins has traditionally been ablative in nature and implemented without intent to improve the haemodynamic condition of the lower extremity veins. Haemodynamic surgery attempts to treat varicose veins by changing the reflux pattern while preserving the most efficient venous drainage channels. To implement this treatment modality it is necessary to have a clear understanding of the physiologic principles and the different reflux patterns that form the basis of haemodynamic surgery. Haemodynamic surgery is an emerging treatment for varicose veins, and has received little attention in the English literature. The rationale, and functional and anatomic basis of haemodynamic surgery for varicose veins are herein described.

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## Introduction

Varicose veins are the most common manifestation of lower extremity chronic venous insufficiency and are a frequent reason for vascular consultation. Although generally regarded as a benign process, varicose veins, because of their high prevalence and the patient demand for treatment, constitute a major issue in most health care systems, with significant cost repercussions. Traditional surgical treatments for varicose veins have generally been ablative and/or obliterative in nature and have involved different procedures, using surgical or mechanical excision and vein obliteration with sclerosing agents, or radiofrequency or laser-generated energy. Despite the wide acceptance of most of these methods, current results of treatment for varicose veins are far from optimal. In contrast with arterial surgery, the traditional approach to the treatment of varicose veins has never focused on the re-establishment or improvement of haemodynamics, perhaps because the haemodynamics of venous pathophysiology have remained poorly understood, and ablative and/or obliterative treatments have been generally implemented with little attention to the preoperative study of venous haemodynamics.

In recent years, duplex scanning has allowed us to improve our understanding of venous physiology, and specifically to unravel the nature of abnormal venous flow patterns in patients with varicose veins. In 1988, Franceschi[1] described a new form of therapy for varicose veins, based on the improvement of the haemodynamic conditions that determine the occurrence of varicose veins. This treatment modality, which also avoids the excision of the saphenous veins, is known as the CHIVA treatment, from the acronym of the French for conservative haemodynamic 'cure' (i.e. treatment) of insufficient veins in ambulatory patients, cure conservatrice et hemodynamique de l'insuffisance veineuse en ambulatoire.

Haemodynamic surgery is a minimally invasive surgical procedure most often used to implement the CHIVA strategy for treatment of varicose veins.

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Theoretically, however, the CHIVA strategy could also be implemented by other technical means such as sclerotherapy, laser catheter or, perhaps, other endovascular means. Haemodynamic surgery for the treatment of varicose veins has been highly debated and often refuted because of its departure from traditional surgery. The continued difficulty in the acceptance and widespread use of this treatment is due to lack of information on its principles, difficulty in learning the strategy and lack of rigorous data supporting its results. Like any other new treatment, haemodynamic surgery is evolving and improving, and we believe it is a worthwhile and promising technique that deserves more attention and scrutiny. It is important to understand that haemodynamic surgery is in evolution and that changes are being incorporated based on the experience of a small number of surgical groups. At present, there is a notable lack of literature to support our review. Therefore, we base our statements on the learning, personal experience and opinions of the authors.

It is the purpose of the present review to explain the rationale of and the anatomic and functional basis of haemodynamic surgery for the treatment of varicose veins.

## Rationale of haemodynamic surgery for varicose veins

Although the precise aetiology of varicose veins is unclear, we do know that there is an alteration in vein wall function, in association with a haemodynamic component that increases venous pressure. Regardless of the initial predisposing factor, it appears that persistence and progression of varicose vein dilatation is mainly secondary to sustained elevation in venous pressure. An intuitive explanation of this phenomenon is given by the Trendelenburg test[2], which can demonstrate the disappearance of varicose vein dilatation with leg elevation and with the application of a thigh tourniquet upon resuming the erect position. Based on this observation, it seems plausible that a reversal in the haemodynamic component of varicose veins could, in turn, produce an involution in the size of the veins and, perhaps, as suggested by Caillard *et al.*[3], be followed by normalization of the ultrasonographic structure of the venous wall. This observation suggests a direct relationship between the haemodynamic and the parietal factor in the development of varicose veins. Haemodynamic surgery is based on the premise that varicose veins regress once the haemodynamic alterations are corrected. Hence, the excision of all varicosities and dilated venous trunks may be unnecessary in the treatment of patients with varicose veins.

Traditional surgery for varicose veins has disregarded the physiologic implications of the surgical removal of the superficial venous system. This attitude ignores the importance of the superficial system in the venous drainage of the soft tissues and assumes that the spontaneous re-organization of venous drainage following ablative surgery for varicose veins is inconsequential. This is far from the truth, since blind ablation of varicose veins eliminates, in many cases, the better drainage routes for the remaining superficial veins, often leaving a poorly drained superficial system prone to the development of new varicosities and clinical recurrence. Haemodynamic surgery attempts to reduce the venous pressure in the superficial system by interrupting the gravitational venous pressure column at the origin of the reflux. Additionally, haemodynamic surgery preserves the veins that empty the superficial system into the deep system by means of hydrostatic forces and an active muscle pump.

The ultrasonographic study of the venous system in patients with varicose veins allows the morphologic identification of dilated venous segments and, more importantly, the drawing of a detailed map of the reflux pattern. Based on this information, haemodynamic surgery designs an individual surgical strategy intended to interrupt the venous pressure column and to preserve adequate routes for effective drainage of the remaining incompetent venous segments.

## Anatomic and physiologic principles of haemodynamic surgery

### Anatomic concepts: venous networks

An understanding of haemodynamic surgery requires a systematic but rather simple classification of the lower extremity veins. The different venous networks are classified depending on their relationship with the lower extremity fascial planes[4]. There are two main fascial planes that compartmentalize the lower extremity: the deep fascia that covers the muscle aponeurosis and the superficial fascia that divides the subcutaneous fat. These two fascial planes delineate three different spaces, as seen in Figures 1 and 2.

The primary venous network, referred to as R1, comprises all the veins located inside the deep fascia and belongs to the deep venous system. The secondary venous network, or R2, comprises the veins contained between the deep and superficial

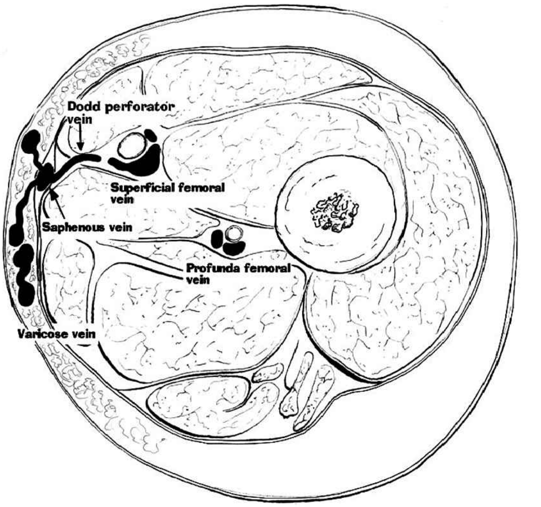


**Figure 1** High thigh cross section illustrating the relationship of the fascial compartments to the deep vein, saphenous vein, superficial varicose veins and perforators

fascia, mainly the greater and lesser saphenous veins, their major branches, and the Giacomini vein. The tertiary venous network, or R3 (Figure 2), corresponds to the veins located outside the superficial fascia, mostly tributaries of the saphenous vein. Finally, the quaternary venous network, or R4 (Figure 2), comprises those veins located superficially to the superficial fascia as the tertiary network, but that connect veins from the secondary network. These R4 veins may be longitudinal if they connect a saphenous vein, or R2, to itself at different levels, or may be transverse if they communicate two different veins from the secondary network (i.e. the greater saphenous with the lesser saphenous vein).

The secondary network is connected to the primary network through the saphenous vein roots and the perforator veins. It is important to remember that not only the saphenous veins are connected to the deep system or primary network through perforating veins; superficial veins from the tertiary network also communicate with the deep system through perforating veins.

## Haemodynamic concepts

Primary varicose veins are characterized by the presence of anomalous retrograde venous flow between different venous networks. Varicose veins originate in veno-venous shunts with an escape point of reflux, which in turn propagates retrograde flow from one venous network into another. The second integral part of a veno-venous shunt is the re-entry point that allows flow from network to network in an antegrade fashion. The veno-venous re-circulation re-enters the deep system through a re-entry point, typically a perforating vein.

Venous shunts can be open or closed, depending on whether they allow blood re-circulation. Closed shunts maintain venous re-circulation during diastole through a refluxing venous segment and cause venous flow and pressure overload. On the other hand, open shunts are haemodynamically benign because retrograde venous flow is unimpeded from one network to another, without re-circulation and without flow overload. In general, limbs with greater clinical severity of venous disease (CEAP clinical severity 3 to 6) are associated with closed shunts with reflux escape points from the deep system to the saphenous veins (R1

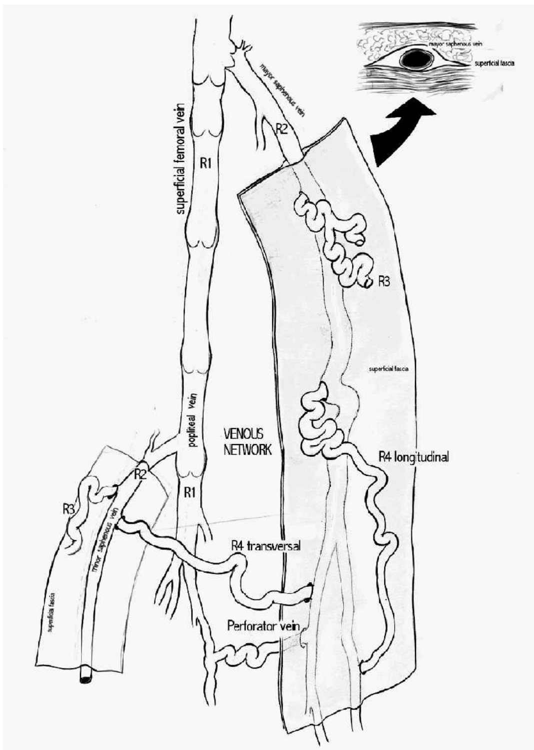


**Figure 2** Diagram illustrating the four different types of venous networks and their connections. The R1 network refers to all deep veins. The R2 network refers to the greater and lesser saphenous veins and the vein of Giacomini. The R3 network refers to tributaries of the saphenous veins. The R4 network is composed of branches of the saphenous veins, which connect both saphenous veins transversely (R4 transversal) or a branch that connects one saphenous trunk to itself at two different levels (R4 longitudinal)

to R2), while open shunts are rarely associated with clinically severe venous disease. The difference in venous flow overload between open and closed shunts is manifested by the degree of saphenous vein dilatation they produce. In open shunts, the saphenous vein calibre is rarely enlarged, while in closed shunts the saphenous vein diameter is almost always dilated. The intrinsic haemodynamic difference between open and closed shunts makes the former generally easier to treat and confers to the latter, in general, a worse prognosis. However, closed shunts in which the escape point can be obliterated, leaving a well drained system, have an excellent prognosis, while certain types of open shunts carry a poor prognosis following haemodynamic surgery.

Most venous shunts allow retrograde flow only during the relaxation phase of the muscle pump mechanism. During muscular systole, reflux tends to cease because of increased pressure at the points of venous re-entry into the deep system. Shunts associated with complete deep vein obstruction, because of their higher pressure gradients, show antegrade flow through both muscle systole and diastole.

The different reflux and shunt patterns have different prognostic implications and require different treatment strategies. To customize treatment to the different patient conditions, haemodynamic surgery classifies venous shunts depending on the venous networks involved and the location of the reflux and re-entry points.

## Classification of venous shunts

As our understanding of the reflux patterns evolves with increasing experience, the classification of different venous shunt configurations encountered in patients with varicose veins has been modified. The classification herein presented is the product of an unpublished consensus reached in 2002 (VII Reunion de L'Association Europeenne de CHIVA, Teupitz, Germany, May 2002). In general, a venous shunt occurs whenever there is anomalous flow (reversed) in any area of the venous system.

### Type 0 shunt

A type 0 shunt consists of a saphenous vein segment with retrograde flow, typically initiated at the level of a not-incompetent R3 tributary, with direct drainage of the refluxing saphenous segment through a perforator into the deep system (Figure 3).

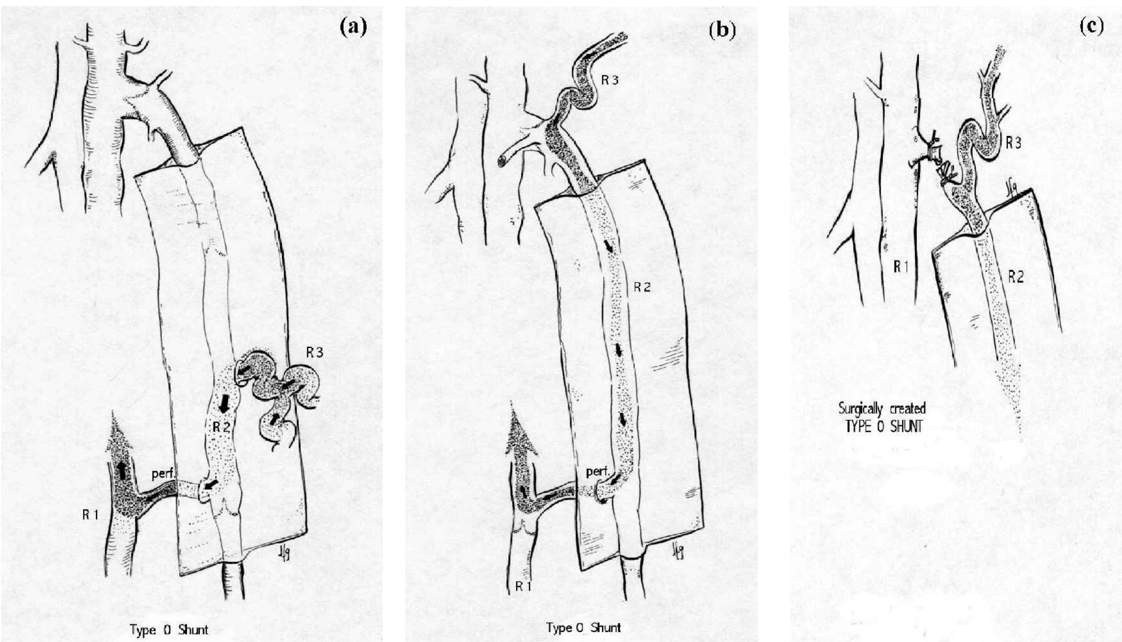


**Figure 3** Type 0 shunts consist of an incompetent saphenous vein segment, originating at a saphenous tributary, which re-enters the deep system directly via a perforator (a). The incompetent saphenous segment can be rather long (b). Regardless of the saphenous vein length involvement, type 0 shunts are haemodynamically benign and are not associated with varicose vein development. A type 0 shunt may be created following high ligation of an incompetent saphenofemral junction (c)

Type 0 shunts are open shunts and do not have any pathologic significance since venous flow is not redundant and drains without impediment into the deep system. A type 0 shunt haemodynamic situation is often the result of surgical intervention, typically following high ligation of the saphenofemoral junction. (Figure 3c).

## Type 1 shunt

In type 1 shunts, the reflux escape point is established between the R1 and R2 networks, with re-entry into the deep system via a perforator vein directly from the saphenous vein. This shunt is considered a closed shunt because there is venous re-circulation through the saphenous vein (Figure 4).

## Type 2 shunt

In type 2 shunts, the saphenofemoral junction is always competent, and the reflux escape point starts off a branch of the saphenous vein (R3 or R4). There are three different type 2 shunts, designated as 2A, 2B, and 2C. In type 2A shunts, the saphenous vein is competent proximal to the escape point off the saphenous vein into the tertiary (R3) or quaternary (R4) networks (Figure 5). In turn, type 2A shunts can be open, if reflux occurs through a transverse R4 travelling from one saphenous vein to another, or through an R3 tributary draining directly into the deep system via a perforator. Type 2A shunts can also be closed shunts if a longitudinal R4 vein connects a saphenous vein to itself at different levels, establishing re-circulation (Figure 5). Type 2B shunts are characterized by the presence of saphenous reflux proximal to the reflux escape point into an R3, with competent flow in the saphenous vein distal to the reflux escape point (Figure 5). Type 2B shunts may have no re-circulation, and therefore are open shunts, when they drain through a perforator. However, they may produce re-circulation if they drain through a longitudinal R4. Type 2C shunts are characterized by saphenous vein reflux proximal and distal to the reflux escape point into an R3 tributary, which drains into the deep system via a perforator. In addition, type 2C shunts present a direct saphenous re-entry into the deep system via a perforator. Type 2C shunts are open shunts because there is no re-circulation.

## Type 1 plus 2 shunt

Type 1 plus 2 shunts are characterized by the presence of both type 1 and type 2 shunts. The haemodynamic situation would be identical to a type 2C shunt, with the addition of a direct reflux escape point between the deep and the saphenous veins, commonly at the saphenofemoral junction. Therefore, these are closed shunts because of re-circulation through the incompetent saphenous vein (Figure 6).

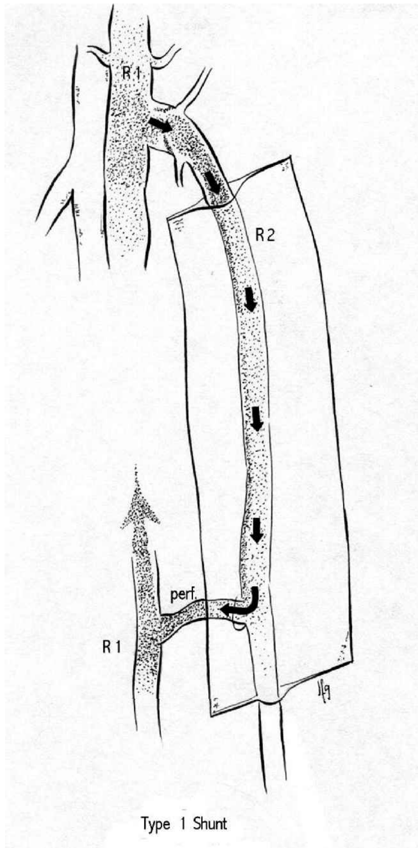


**Figure 4** A type 1 shunt occurs when the saphenofemoral junction is incompetent and a segment of the saphenous vein refluxes distally until flow re-enters the deep system through a perforating vein

## Type 3 shunt

This is the most common type of shunt in patients with primary varicose veins. The reflux escape point arises between the deep and the saphenous veins (R1 to R2), commonly at the saphenofemoral junction, and reflux continues into an R3 tributary, which drains in turn into the deep system via a perforator. Type 3 shunts are closed shunts because of re-circulation through the saphenous vein and R3 tributary (Figure 7).

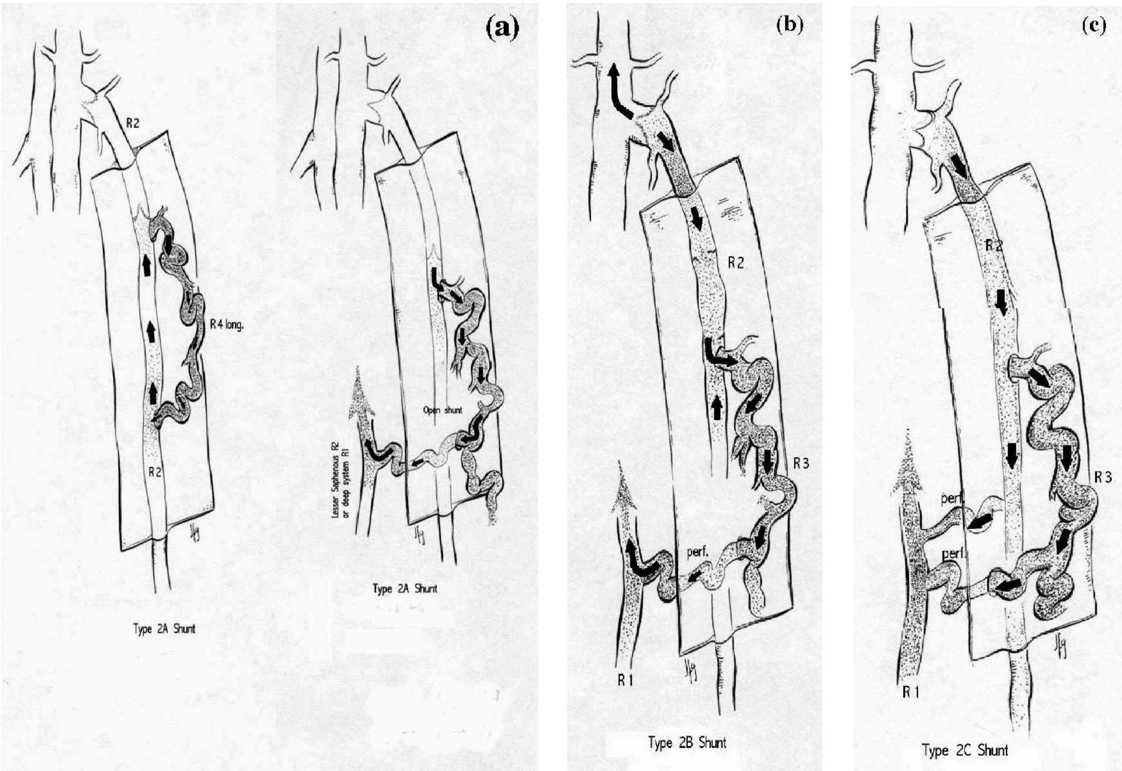


**Figure 5** All type 2 shunts have a competent saphenofemoral junction. Type 2A shunt occurs when a direct tributary of the saphenous vein (R3) refluxes, re-entering the saphenous trunk at a more distal level (a). The saphenous vein is competent throughout. Type 2A shunts are closed, re-circulating shunts if the re-entry is at the same saphenous trunk, or they can be open shunts if reflux re-enters another saphenous trunk (i.e. the lesser saphenous) or the deep system via a perforator. In type 2B shunts, the saphenous vein is incompetent proximal to the tributary (R3) escape point, with a competent saphenofemoral junction, and re-entry is via a perforator into the deep system (b). In type 2C shunts, the saphenous vein refluxes distal to the reflux escape point and re-enters the deep system via a second perforator (c)

## Type 4 shunt

Type 4 shunts are characterized by an origin of reflux in an incompetent perforator off the deep system, which connects to an R3 tributary that drains into the saphenous vein. The saphenous vein is rendered incompetent distal to the R3 connection, and a distal saphenous perforator re-enters the deep system. Type 4 shunts originating in a deep perforator produce re-circulation. Likewise, type 4 shunts originating in an incompetent pelvic R3 vein also produce re-circulation and would be closed shunts (Figure 8). This is evidenced by the presence of reflux in the originating R3 tributary during a Valsalva manoeuvre.

## Type 4 plus 2 shunt

Type 4 plus 2 shunts are characterized by the association of a type 4 with a type 2 shunt. The reflux escape point originates in a perforating vein or in a pelvic R3 tributary that renders the saphenous vein incompetent from its entry. Re-entry occurs through a saphenous perforator and through an R3 tributary that drains into the deep system via a perforator (Figure 9). These are considered closed shunts since their global haemodynamic effect produces re-circulation.

## Type 5 shunt

In type 5 shunts, the reflux escape point is similar to that in type 4 shunts. Reflux may initiate through a pelvic R3 (Figure 10a) or through an incompetent perforator (Figure 10b). The re-entry is established through an R3 into the deep system via a perforator. Type 5 shunts are all closed shunts since the pelvic veins in which they may originate are

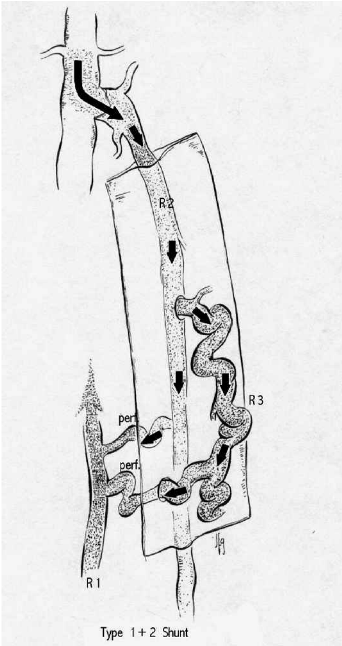


**Figure 6** Type 1 plus 2 shunts are identical to type 2C shunts, with the addition of saphenofemoral junction reflux

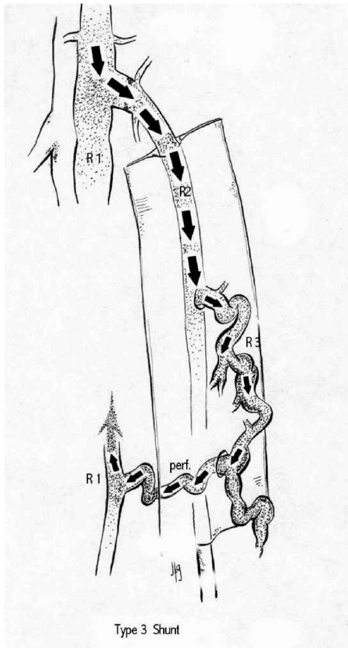


**Figure 7** A type 3 shunt – the most common reflux pattern. Reflux arises at the saphenofemoral junction and flows through the saphenous trunk into a tributary that eventually drains into the deep system via a perforator

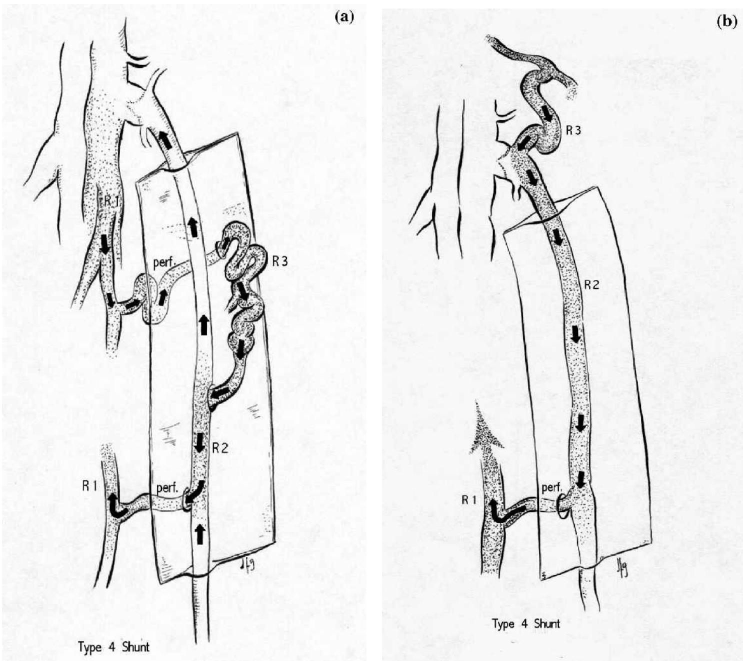


**Figure 8** Type 4 shunts can originate in a perforator or a pelvic vein. Incompetent pelvic R3 veins in turn originate in the iliac vein, which is also considered an R1 segment. They connect to the saphenous trunk, which becomes incompetent, and the more distal saphenous drains into the deep system via a perforator. Both types produce re-circulation

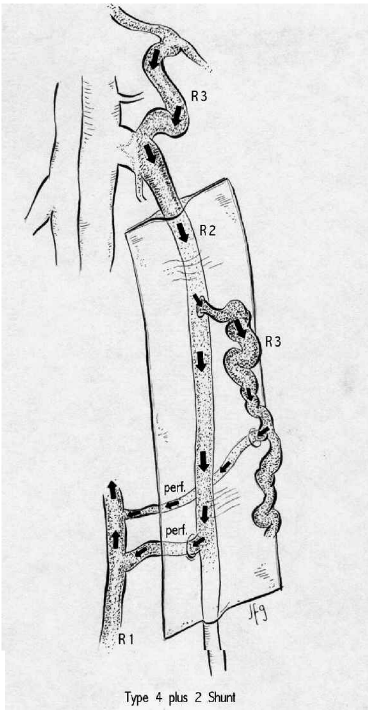


**Figure 9** In type 4 plus 2 shunts a type 4 shunt has an additional incompetent tributary (R3) that refluxes and re-enters the deep system via another perforator. Incompetent pelvic R3 veins originate in the iliac vein, which is also considered an R1 segment

avalvular and can potentially generate re-circulation. Type 5 shunts are likewise closed if they originate in an incompetent perforator.

## Type 6 shunt

In type 6 shunts, the saphenous vein is not involved. The reflux escape point arises from the deep system (R1) into an R3 which drains directly into the deep system via a perforator or, alternatively, into a competent saphenous vein (Figure 11). Type 6 shunts are open shunts when they drain into a competent saphenous vein and are closed when drainage is through a perforating vein.

## Collateral shunts

Collateral shunts are those generated in response to a venous obstruction. In collateral shunts, venous flow is antegrade throughout muscle pump systole and diastole, and they are not necessarily associated with reflux.

This shunt classification includes most reflux patterns encountered in patients with varicose veins. It allows us to classify the different haemodynamic configurations that we may encounter in patients with superficial venous incompetence and to select accordingly the most appropriate surgical strategy. In addition, it has prognostic implications.

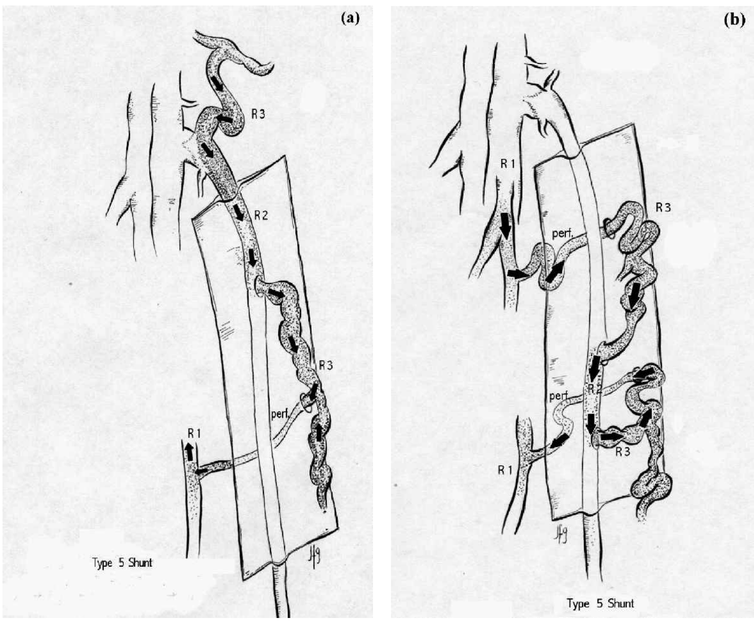


**Figure 10** Type 5 shunts originate in the same way as type 4 shunts, but they drain into the deep system via perforators arising in saphenous tributaries rather than from the saphenous vein. The incompetent pelvic R3 vein that creates the shunt originates in the iliac vein (R1)

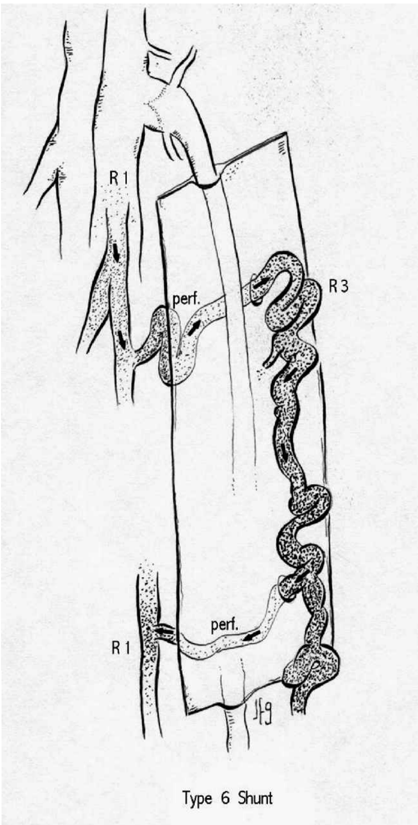


**Figure 11** In type 6 shunts, the saphenous vein does not reflux. The reflux escape point arises from a perforating vein and renders an R3 tributary incompetent; this in turn drains into the deep system or, alternatively, into a competent saphenous vein

Although the results of haemodynamic surgery for varicose veins are encouraging in many respects, the late results and haemodynamic consequences are still uncertain[5].

The aforementioned concepts are necessary in order to understand the formulation and implementation of a treatment plan for varicose veins based on the CHIVA strategy. In a subsequent publication, we will discuss the CHIVA strategy and its implementation through haemodynamic surgery.

## Acknowledgement

Competition of interest: nil.

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