Review article

Haemodynamic surgery for varicose veins: surgical strategy

J Juan*, JM Escribano*, E Criado† and J Fontcuberta‡
*Hospital Vall d'Hebron, Barcelona, Spain; †Divisions of Vascular Surgery, Department of Surgery, Stony Brook University, New York, USA; ‡Complejo Hospitalario de Toledo, Toledo, Spain

Abstract
The haemodynamic approach for the treatment of varicose veins is a minimally invasive, non-ablative procedure that that preserves the saphenous vein. The strategic principles for the implementation of this treatment include fragmentation of the venous pressure column, the interruption of the venous segments where reflux originates, preserving the superficial venous outflow channels to allow adequate drainage of the residual superficial system, and excision of the superficial varicose veins that remain undrained. This treatment modality requires a thorough understanding of the haemodynamic and anatomic rationale on which haemodynamic surgery is construed to tailor a treatment plan individually for each patient. The principles for the implementation of this strategy for the treatment of varicose veins are described here and the results are discussed.

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Keywords: Varicose veins; haemodynamic surgery; CHIVA

Introduction

Haemodynamic surgery for the treatment of varicose veins is based on the premise that varicose veins are the consequence of a pathological venovenous shunt that creates recirculation of venous blood between the deep and the superficial system (Figure 1). In 1998, Francheschi described the procedure known as conservative haemodynamic cure of venous insufficiency on an ambulatory basis, known by the French acronym CHIVA (cure conservatrice et hemodynamique de l'insuffisance veineuse en ambulatoire). The understanding of this surgical strategy requires knowledge of the anatomic and physiological principles on which haemodynamic surgery for varicose veins is based, and the different types of venous shunts that occur more commonly.[1] The application of haemodynamic surgery for the treatment of varicose veins is based on four strategic principles, which include:

1. fragmentation of the venous pressure column (Figure 2);
2. interruption of the venovenous shunt (Figure 3);
3. preservation of re-entry perforating veins (Figure 4);
4. suppression of the tertiary and quaternary venous networks that remain undrained (Figure 5).

This surgical strategy pursues the establishment of a venous network in which the reflux venous outlets are interrupted, while antegrade or retrograde superficial venous return remains unimpeded into a competent deep venous system.

An important concept in the understanding of the surgical strategy for haemodynamic surgery is the fact that retrograde flow through a venous segment drained into the deep system through a

Correspondence: **Dr E Criado MD**, Chief, Division of Vascular Surgery, Department of Surgery, Health Sciences Center T-18, Room 040, Stony Brook University, Stony Brook, NY 11794-8191, USA.
Email: ecriado@notes.cc.sunysb.edu

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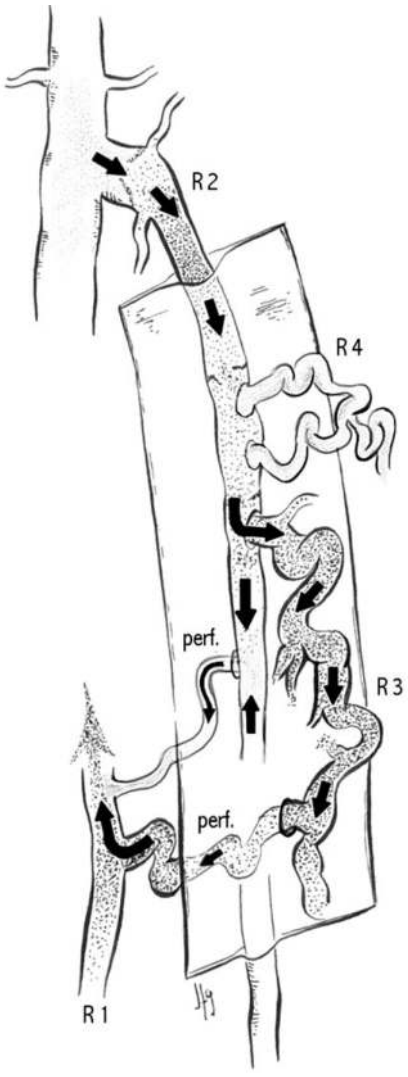

Figure 1 Haemodynamic concept of varicose veins: venous varices are the consequence of a pathological venovenous shunt that perpetuates recirculation of venous blood between the deep and superficial venous systems

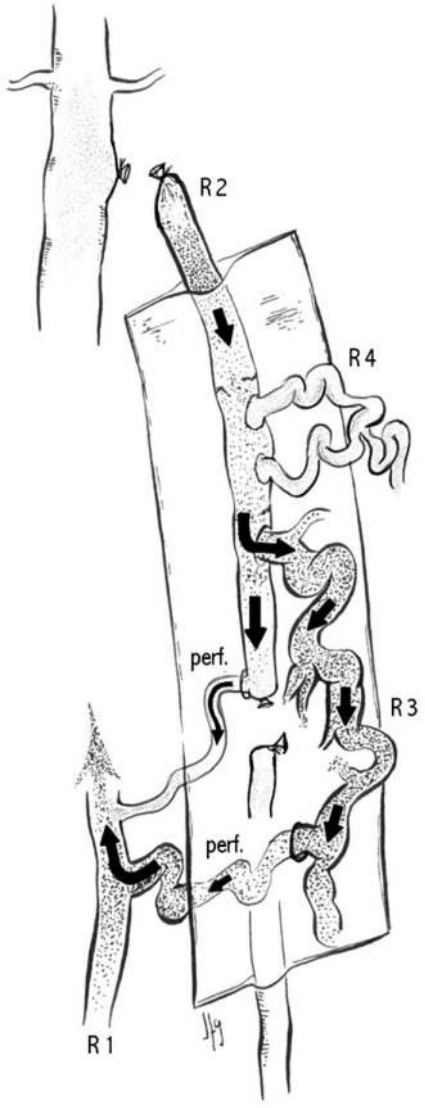

Figure 2 Fragmentation of the venous pressure column is usually accomplished by ligation of the origin of the incompetent venous segments. Occasionally, this can be done with ligation of the saphenous vein just distal to a perforator draining the saphenous vein into the deep system

perforating vein may constitute an adequately drained superficial venous system. This type of haemodynamic situation, classified as type 0 shunt,[1] is found with a certain frequency in the saphenous vein of normal individuals.

Haemodyanamic surgery strategy

CHIVA 1 strategy

The CHIVA 1 strategy is the application of all the principles of haemodynamic surgery in a single procedure without compromising the venous outflow, by creating a well-drained system. This type of surgical strategy is applicable to type 1 shunts (Figure 6), type 2 shunts (Figure 7), type 1 plus 2 shunts (Figure 8), type 4 shunts (Figure 9), type 4 plus 2 shunts (Figure 10), type 5 shunts (Figure 11), and type 6 shunts (Figure 12). In all these cases, the interruption of the reflux exit point can be done in conjunction with the interruption of R3, without creating a haemodynamic conflict. In case of type 3 shunts, the application of the CHIVA 1 strategy only allows interruption of the reflux point from R1 to the R2 system (Figure 13). This improves venous haemodynamics, but the R3 tributaries remain

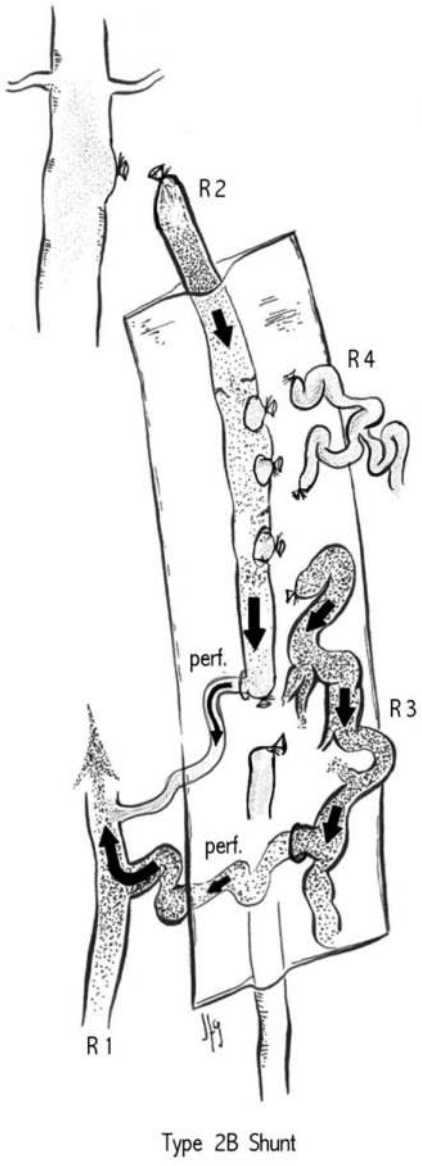

Figure 3 Interruption of reflux exit points

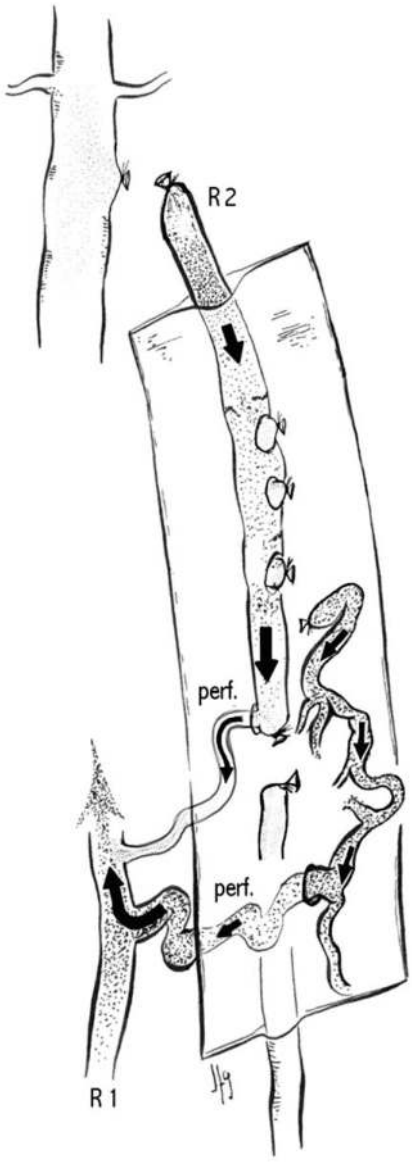

Figure 4 Preservation of re-entry perforators into a competent deep system

filled from antegrade flow from the distal saphenous vein, thereby producing unsatisfactory immediate cosmetic results because the R3 varicose tributaries remain visible.

CHIVA 2 strategy

The CHIVA 2 strategy consists of the application of the haemodynamic surgery principles in two-staged, separate procedures. This treatment modality is advisable for the treatment of type 3 shunts, to avoid the creation of venous outflow compromise. In the first stage, the secondary reflux point from the R2 to R3 venous systems is interrupted (Figure 14), leaving the main reflux point from R1 to R2 uncorrected. The initial interruption of the secondary reflux point forces antegrade flow through the greater saphenous vein. In most cases, this haemodynamic rearrangement stimulates development of a new re-entry perforator from R2 to R1 (from the saphenous vein to the deep system), transforming a type 3 shunt into a type 1 (Figure 15).

Once the new perforator acquires sufficient development, manifested by a greater retrograde flow during muscular diastole than antegrade flow during systole, the R1–R2 reflux point can be interrupted (Figure 16). In cases where the

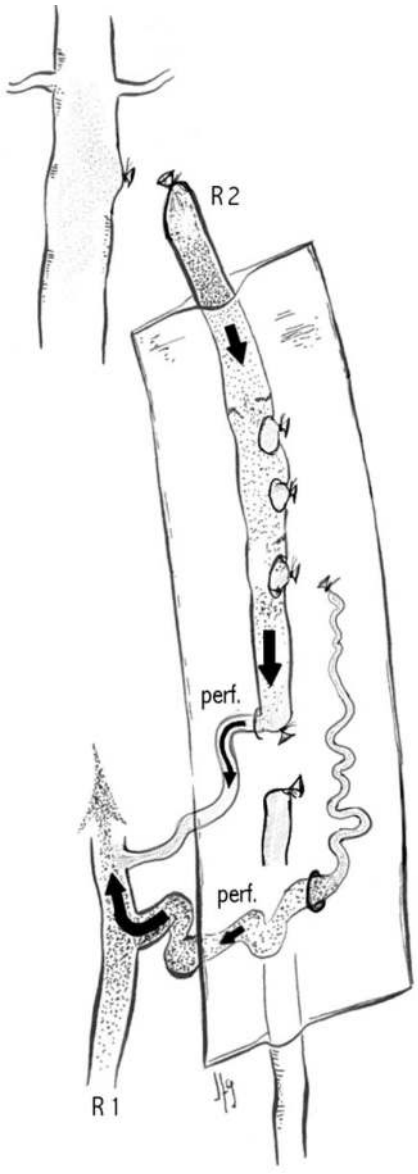

Figure 5 Excision of the non-drained tertiary and quaternary superficial system

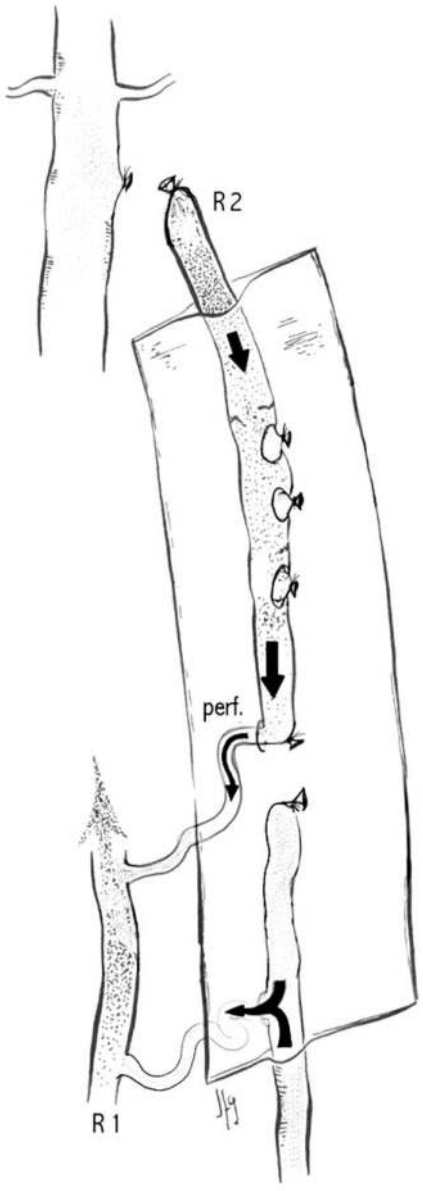

Figure 6 CHIVA 1 strategy in a type 1 shunt

saphenous vein caliber is large (i.e. >1 cm), the CHIVA 2 strategy is contraindicated because of the risk of saphenous vein thrombosis and potential thrombotic extension into the deep system, while the saphenofemoral junction remains open.

The CHIVA 2 strategy may also be indicated in type 4 plus 2 and type 5 shunts when the main reflux point presents difficult surgical access, as in shunts originating in the pelvis. In general, the low flow of such main reflux points makes unnecessary their interruption in a second-stage procedure.

It is important to understand that the implementation of this staged surgical strategy for haemodynamic surgery requires periodic evaluations with duplex scanning to estimate the flow pattern in the saphenous vein, to determine when it is appropriate to ligate the main reflux point at the saphenofemoral junction.

CHIVA 1 plus 2 strategy

The CHIVA 1 plus 2 strategy consists of the application of all the strategic principles of haemodynamic surgery in a single surgical intervention, despite generating a haemodynamic venous outflow conflict. This strategy is applicable to type 3

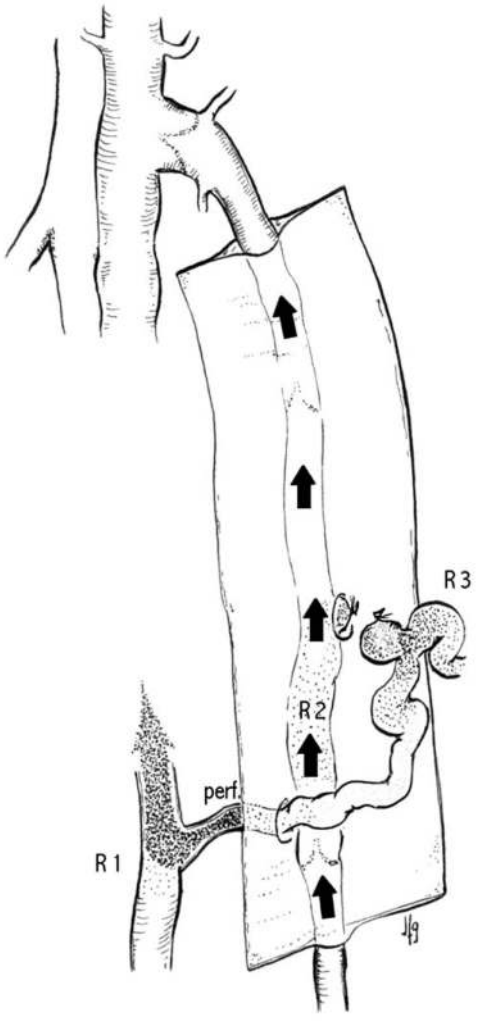

Figure 7 CHIVA 1 strategy in a type 2 shunt

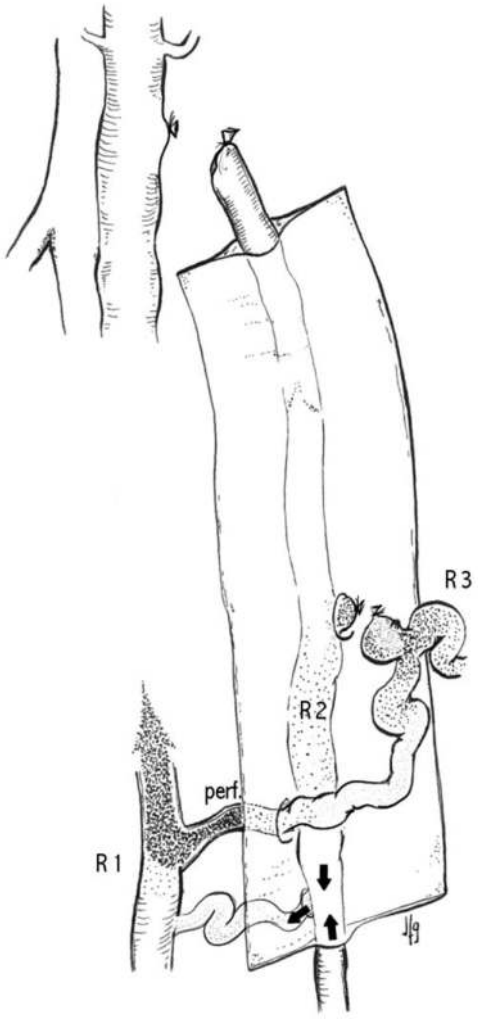

Figure 8 CHIVA 1 strategy in a type 1 plus 2 shunt

shunts, interrupting the main and secondary reflux points simultaneously (Figure 17).

This strategic option is only a partially haemodynamic modality, since it interrupts the reflux points without an appropriate rearrangement of the venous outflow of the superficial system. With this strategy, a substantial number of cases develop a new perforating vein off the saphenous trunk, which suffices for adequate drainage. In other cases, the venous drainage is re-established through a new R3 tributary that may be visible and may warrant cosmetic excision or sclerotherapy.

A major drawback of the CHIVA 1 plus 2 strategy is the associated high incidence (50%) of saphenous vein thrombosis. However, this thrombosis is followed by recanalization, in most cases, usually within 12 months of the procedure, and it does not compromise the final drainage of the venous segment. The advantage of this strategy is that it only requires clinical follow-up, and ultrasound re-evaluation is only necessary in cases of recurrence. Therefore, the CHIVA 1 plus 2 strategy is more appropriate for health-care systems where repeated follow-up ultrasonography is not possible.

Indications and patient selection for haemodyamic surgery

Any patient with primary varicose veins, who is a candidate for phlebo-extraction, is suitable for haemodynamic surgery. The size of the saphenous vein and that of the varicose veins at the time of surgery do not appear to influence the results of haemodynamic surgery at three years of follow-up.[2] Therefore, haemodynamic surgery is

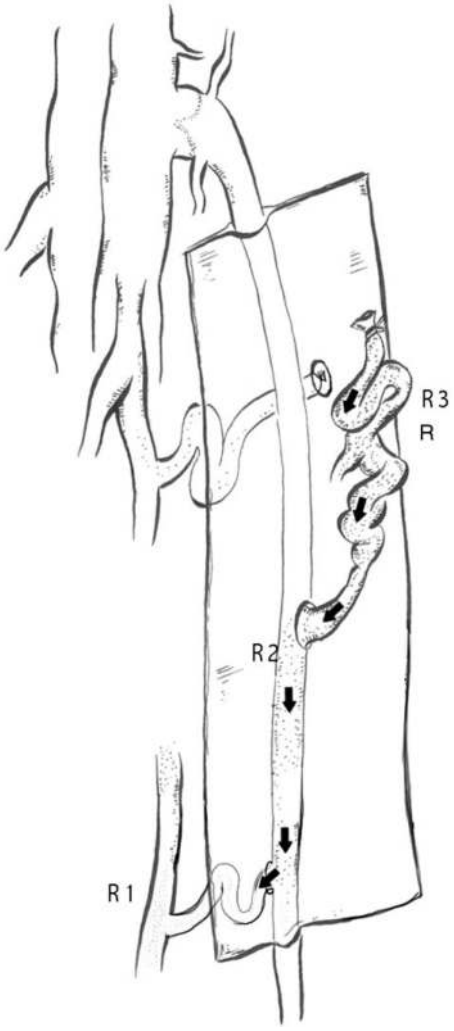

Figure 9 CHIVA 1 strategy in a type 4 shunt with a surgically accessible reflux point

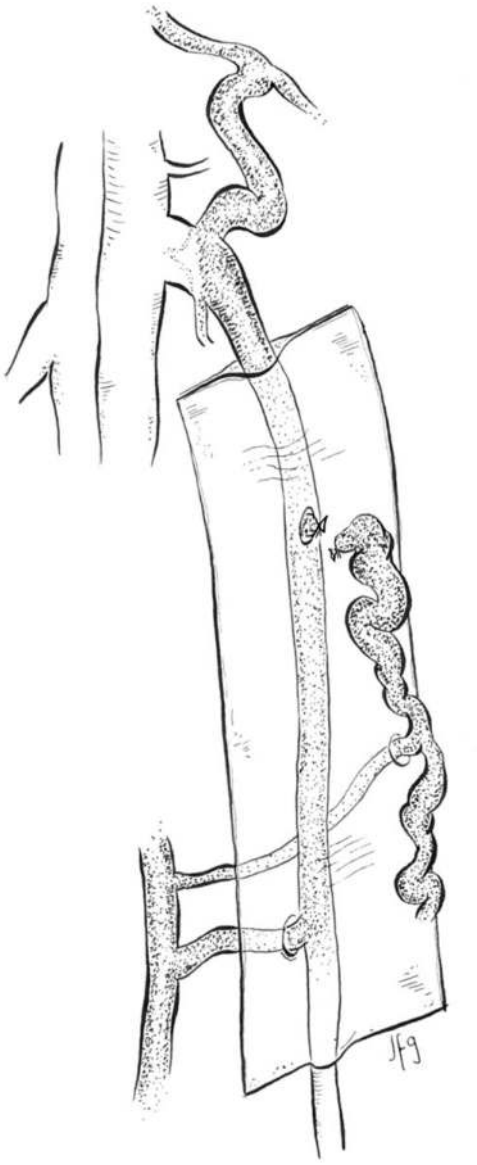

Figure 10 CHIVA 1 strategy in a type 4 plus 2 shunt with a surgically accessible reflux point

applicable regardless of the size or number of the varicose veins.

In the case of secondary varicose veins, haemodynamic surgery may be applied when the varicose veins do not represent the main collateral venous outflow, but are simply a venovenous shunt. This haemodynamic situation can be demonstrated by the identification of retrograde flow in the venous segment during muscular diastole using the Parana maneuver.[3] In such cases, haemodynamic surgery may produce clinical and haemodynamic improvement.

The differentiation between venous outflow collaterals and varicose veins is likewise important when conventional treatment of varicose veins is applied, because their excision is contraindicated.

An important factor in the selection of patients for haemodynamic surgery is their ambulatory capacity. It is essential that patients undergoing haemodynamic surgery for varicose veins are capable of ambulating immediately after surgery to activate the superficial venous return immediately after surgery. Therefore, patients with ambulatory limitations are not good candidates for haemodynamic surgery for varicose veins.

The minimal invasiveness of haemodynamic surgery makes the technique applicable to patients of advanced age or with co-morbidities in the presence of symptomatic venous reflux.

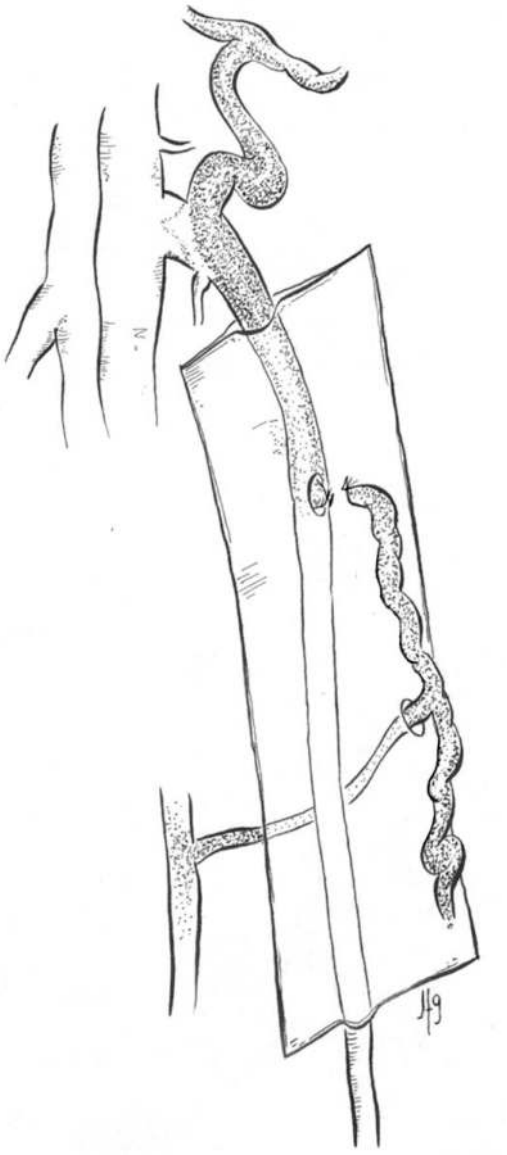

Figure 11 CHIVA 1 strategy in a type 5 shunt with a surgically accessible reflux point

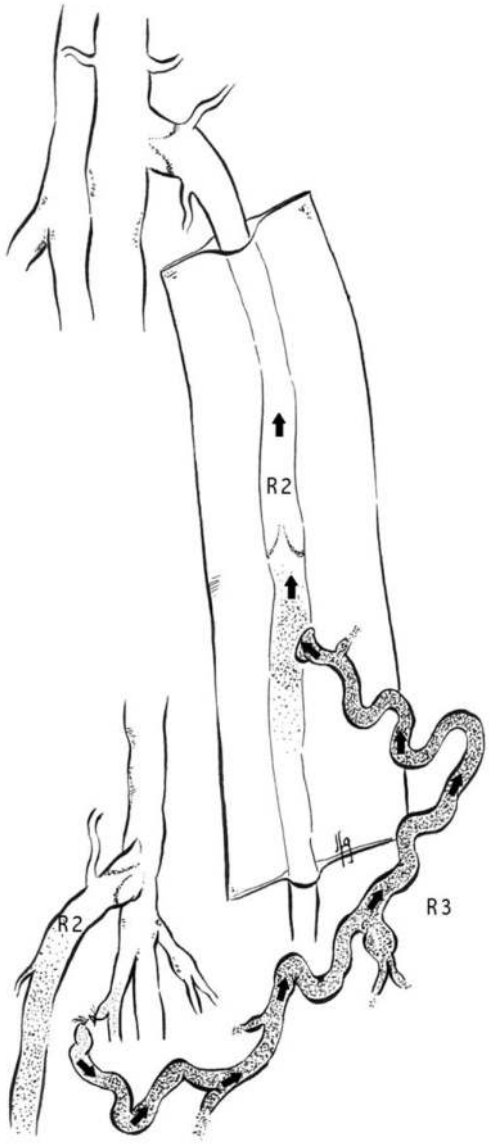

Figure 12 CHIVA 1 strategy in a type 6 shunt with a surgically accessible reflux point

Preoperative venous marking

Immediately before the surgical procedure, the patient is evaluated in the peripheral vascular laboratory with duplex ultrasound, done in the standing position. The venous reflux points are identified, as well as the venous re-entry points from the superficial to the deep system. The Valsalva and Parana maneuvers are used routinely to identify the reflux patterns in the different venous segments. The type of venous shunt is elucidated, the surgical strategy delineated with skin markings, and the venous segments that have to be excised are marked.

The Perthes manoeuvre is helpful in identifying perforating veins that allow adequate drainage of varicose vein clusters that therefore do not need to be excised. A rubber tourniquet applied above the cluster maintains the varicose veins collapsed during activation of venous return with the calf muscle pump. If the varicose veins remain filled, the manoeuvre is repeated progressively with more distal tourniquet placement until the superficial tertiary varicose network disappears. In such cases, the varicose segment proximal to the tourniquet site should be excised.

The skin markings are done with the extremity shaved in preparation for surgery, and can be done

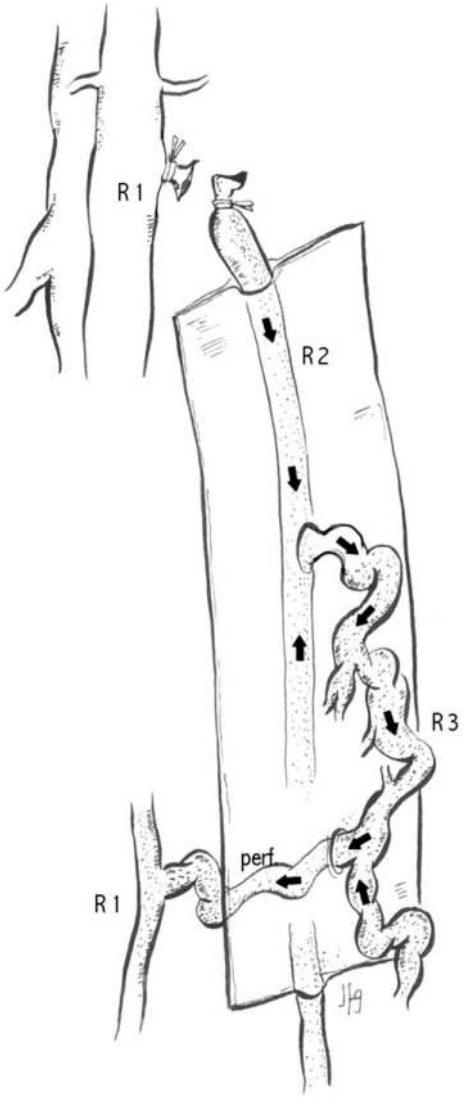

Figure 13 CHIVA 1 strategy in a type 3 shunt. The cosmetic results are poor because the tertiary network and the antegrade colaterals of the proximal, incompetent saphenous segment remain filled from antegrade flow from the saphenous vein distal to the R3 tributary

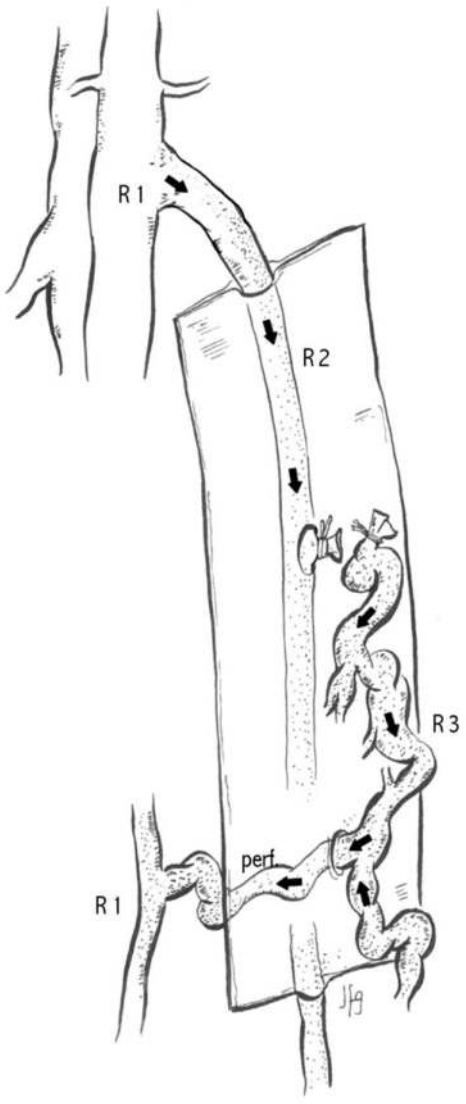

Figure 14 First stage of a CHIVA 2 strategy: interruption of a reflux exit point from R2 to R3 (saphenous vein to varicose tributary)

on the day of surgery or the day before. The patient should be instructed to avoid the use of skin lotions or creams that may prevent marking of the skin. The patient should not wash the skin prior to surgery to avoid losing the skin marks. Ideally, the skin marking is done in the presence of the operating surgeon to facilitate identification of the surgical strategy at the time of surgery. After the skin marking is completed, a diagram detailing the location of the venous interruptions and other anatomical details is done on paper to serve as a guide to the operating surgeon. This diagram also aids in the postoperative follow-up of the patient.

Surgical procedure

The operating surgeon should carefully review the diagram with the surgical plan constructed at the time of skin marking. The operation is done under local anaesthesia, although occasionally conscious sedation is necessary. In cases of reoperation at the level of the saphenofemoral junction, regional anaesthesia may be required. In case of bilateral varicose veins, the operation is preferably done on one extremity at a time to limit the amount of local anaesthetic, and to facilitate immediate postoperative ambulation.

Monofilament nonabsorbable sutures are recommended for ligation of axial venous trunks, to reduce the development of neo-vascularization.

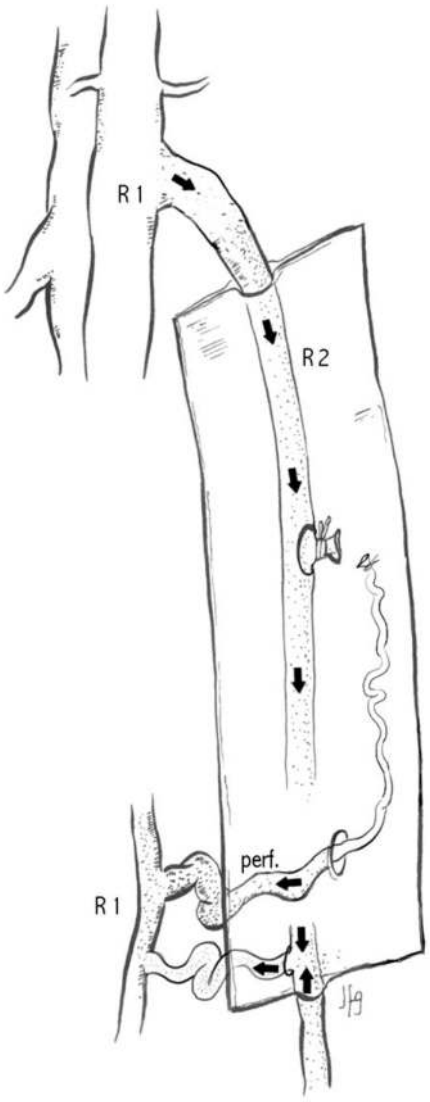

Figure 15 CHIVA 2 strategy: conversion of a type 3 shunt into a type 1 shunt following the first stage of the strategy

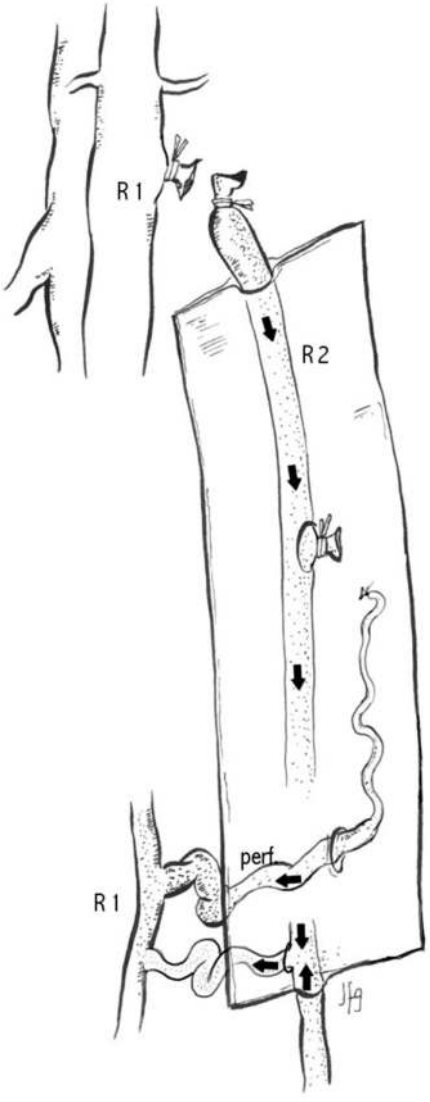

Figure 16 Second stage of a CHIVA 2 strategy: interruption of a reflux exit point from R1 to R2 (saphenofemoral junction) after development of a distal perforator from the saphenous trunk into the deep system

Because of potential recanalization of isolated venous ligatures, and the neo-angiogenic potential of pressurized venous cul-de-sacs, all venous ligations should be done flush on the proximal vein, without leaving a stump, and a segment of vein should be resected, mainly at the level of the saphenofemoral junction.

The strategic surgical incisions are marked over the reflux points that have to be ligated and transected, and need to be large enough to allow good visualization. The secondary incisions are small cosmetic incisions utilized to excise the undrained varicose veins. The stab avulsion technique is recommended for optimal cosmetic results.

A compression wrap is placed on the calf, and a small bandage in the groin incision is applied when necessary. Ambulation is resumed immediately after surgery, and typically the patient leaves the operating room walking. The patient is given instructions to walk several hours a day, in the morning and afternoon, to promote the immediate involution of the interrupted venous shunts, and to prevent thrombosis of venous segments with potentially compromised outflow.

The patient is prescribed low molecular weight heparin at prophylactic doses for seven days, and pain medication. Unilateral limb surgery is less painful and allows immediate re-ambulation better than a bilateral intervention.

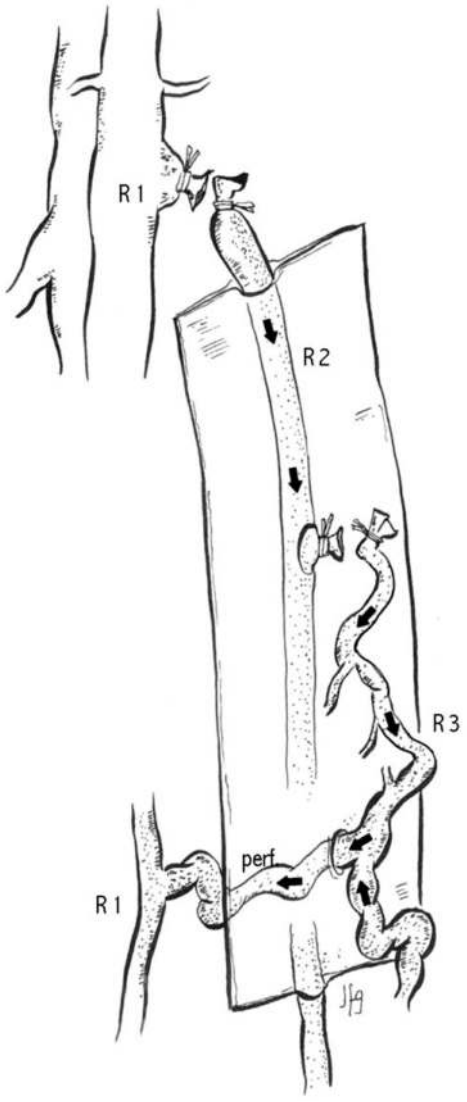

Figure 17 CHIVA 1 plus 2 strategy: interruption in a single procedure of the reflux exit points between R1 and R2 and between R2 and R3

Immediate and long-term follow-up

The patient is seen one week after surgery for a wound check and the skin stitches, if applied, are removed. A knee-high elastic stocking of 20–30 mmHg of compression gradient is then prescribed for one month.

After the first stage of a CHIVA 2 procedure, a strict follow-up with duplex ultrasound is necessary to determine the appropriate timing of the ligation of the saphenofemoral junction, the second surgical stage of this strategy. Our follow-up protocol in these patients includes duplex evaluation at three, six, 12, and 24 months after the initial procedure. Ligation of the saphenofemoral junction is indicated when reverse flow in the saphenous vein re-appears following development of a new perforator from the saphenous to the deep system. This occurs within three months in 80% of patients, and in up to 90% at 12 months.[2] Development of a new saphenous perforator transforms a type 3 shunt into a type 1 shunt, which, if not interrupted, will produce new tertiary (R3) varicose veins. Patients with smaller saphenous veins (<5 mm diameter measured at 15 cm distal to the saphenofemoral junction) are more likely to maintain antegrade sapheous vein flow, as this occurs in up to 50% of these patients.[2,5]

In patients undergoing CHIVA 1 or CHIVA 1 plus 2, the follow-up is not different from that of patients undergoing conventional surgery for varicose veins. In these patients, duplex ultrasound is indicated only when varicose vein recurrence occurs.

Results of haemodynamic surgery

Results of haemodynamic surgery for varicose veins depend mainly on three factors:

1. the obtainment of a well-drained superficial venous system, which will predictably be followed by better mid- and long-term results;
2. the type of venous shunt under treatment. Type 2B and type 5 shunts have a higher incidence of varicose vein recurrence (R3).
3. the surgical technique, as long saphenous vein stumps at the saphenofemoral junction or at any other venous interruption site, and ligation of venous segments without complete interruption are often a source of recurrence.

Clinical improvement and complications

The clinical results of haemodynamic surgery for varicose veins at three years of follow-up following Hobbs[6] criteria reveal that 83–89% of patients were cured or experienced significant improvement; 10–14% were slightly improved; and 0–1% had no improvement or got worse.

Patients undergoing a non-drained operation (CHIVA 1 plus 2) have a significantly higher clinical and ultrasonographic evidence of varicose vein recurrence.[2,7,8] A randomized comparison of the CHIVA strategy against saphenous vein stripping suggests that, at two years of follow-up, there is no significant difference in clinical results

between both treatment modalities, but there is a trend towards better long-term results with the CHIVA technique.[9]

In our experience, the incidence of saphenous nerve injury or neuralgia with the CHIVA technique ranges from 1% to 5%, without any disabling consequences, and the incidence of wound infection is less than 1%.[2,7]

Ultrasonographic changes during follow-up

The evolution of the greater saphenous vein diameter shows an average reduction of 3 mm.[2,7] The incidence of saphenous vein thrombosis following the CHIVA 1 plus 2 strategy ranges from 40% to 59%,[8] while after the CHIVA 2 it is less than 10%.[2,5,7] Saphenous vein thrombosis following CHIVA is usually asymptomatic, but is more likely to present with symptoms when the saphenous vein diameter is greater than 8.5 mm. For this reason, non-drained CHIVA strategies should be avoided in patients with larger saphenous vein diameters.[10]

Saphenous vein thrombosis spontaneously evolves to recanalization in most cases within six months.[7,10] Thrombosis of the saphenous vein, however, does not preclude later development of perforators that will drain the incompetent segment into the deep system, but on the other hand may be associated with a higher recurrence rate of new varicosities.[7]

Advantages and disadvantages of haemodyamic surgery for varicose veins

Haemodynamic surgery for varicose veins has some clear advantages over conventional greater saphenous vein stripping, including immediate return to physical activity and minimal work disability,[10] lower incidence of saphenous nerve injury, and a significantly lower incidence of postoperative development of telangectasias, probably due to adequate drainage of the subcutaneous venous system.[8] In addition, the preservation of the saphenous vein as a conduit for possible future vascular reconstruction is also an appealing advantage of this technique. The preservation of pelvic shunt drainage into the saphenous system with the CHIVA technique allows a decrease in the recurrence of pelvic varicosities, which is common and difficult to treat following saphenous vein stripping.[8]

The indications and contraindications for surgery are similar for haemodynamic surgery and conventional saphenous stripping. It is important to remember that the results of haemodynamic surgery for varicose veins are not influenced by the size or extent of the varicose veins.[8]

A disadvantage of haemodynamic surgery is the need for periodic ultrasound control in those patients undergoing a CHIVA 2 strategy until the second stage of the procedure is indicated.

An important limitation of haemodynamic surgery is the requirement for a very detailed ultrasound evaluation of the incompetent venous system, because it requires extensive experience and skills in venous ultrasonography, and lengthy training and supervision are necessary to reach confidence and success with the technique.

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