SAPHENOUS SPARING TREATMENTS SHORT REVIEW

CHIVA strategy in the treatment of venous insufficiency

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Abstract The approach to the diagnosis and treatment of venous insufficiencies involves two opposing attitudes: demolition and conservation of the venous system. CHIVA is based on knowledge of the pathophysiology of venous insufficiency. Through an accurate and standard echo color Doppler investigation, a mandatory method that must be within the capabilities of a modern phlebologist, the causes of the increase in transmural pressure are identified, a map is prepared and finally a therapeutic strategy aimed at normalizing the transmural pressure is planned. CHIVA represents a scientific progress in the approach to venous insufficiency. The CHIVA strategy is applied mainly, but not only, with conservative surgical tactics based on the faithful reproduction of the strategy planned with the cartography. CHIVA respects venous function and seeks to preserve the GSV useful for all arterial surgery needs. Studies performed according to the rules of evidence-based medicine, Cochrane reviews and meta-analyses certify the validity of the CHIVA strategy in the treatment of venous insufficiencies of the lower extremities.

Keywords TransMural Pressure (TMP), Shunt, echo-Doppler, cartography, strategy

Introduction

CHIVA is the French acronym for "Cure conservatrice et Hemodynamique de l'Insuffisance Veineuse en Ambulatoire": conservative and hemodynamic treatment of venous insufficiency in out-patients. This treatment was proposed by Claude Franceschi in 1988[1-3]. It is based on a hemodynamic model of the venous pathophysiology where venous insufficiency is defined as the inability of the venous system to maintain a normal venous trans-mural pressure TMP, to fulfill its functions of tissue drainage, right heart pre-load, and thermoregulation. So, the excess of TMP is regarded as the cause of the symptoms and signs of venous insufficiency. Consequently, restoring a normal TMP is considered mandatory and sufficient to cure this disease.

The venous system is made of cardiac, thoraco-abdominal, muscular pumps, venous network, and venous side of the micro-circulation. The TPM excess can be due to the malfunction of one or more of its components. TMP is the pressure resulting from the intra-venous pressure (IVP) and the extra-venous pressure (EVP) opposition. So, it increases with the rise of IVP, the decrease of EVP, and vice versa. IVP is composed of Residual Pressure (RP) provided by the arterial pressure through the micro-circulation resistance, Gravitational Hydrostatic Pressure (GHP) proportional to the vertical height of the venous blood column and Valvular Muscular Pump Pressure (VMPP) provided by the Valvular Muscular Pumps (VMP).

CHIVA assesses and corrects specifically the GHP, VMPP and RP excesses. By fractioning the venous blood column, it corrects the Dynamic Fractioning of the Gravitational Hydrostatic Pressure (DFGHP) impaired by valve incompetence. It reduces the VMPP excess by disconnecting the source of the diastolic overloading flows and pressure. It prevents excessive RP by preserving the drainage through the original and compensatory veins. For the same reason, it preserves also any vein even if varicose and/or refluxing provided it suppresses the overloading component of the reflux.

A flow is physiologically correct whatever its antegrade or retrograde direction, provided it is made only of the draining blood of its area (venosome)[4-6]. It is conservative for hemodynamic reasons, i.e restoring a proper TMP which results in the cure of signs (cosmetics included) and symptoms of venous insufficiency. As the venous insufficiency cases are more or less complex according to their hemodynamic configuration, CHIVA strategy must be tailored for each anatomical-functional configuration.

Some pioneers can be considered CHIVA precursors[7] because they related the fluid mechanics to the venous pathophysiology (Table 1). They described the reverse flow in the dilated great saphenous veins (GSV), the excess of pressure caused by a defect of blood column fragmentation due to valve incompetence, and favorable evolution of leg ulcers after high ligation of the GSV.

Some decades after Benjamin Brodie[8], Friedrich Trendelenburg[9] (1890) observed that the varicose GSV compressed with a finger at the groin on a recumbent patient, inflated less quickly when standing up if he kept the pressure than when he released it (Trendelenburg Test). Georg Perthes, his assistant, noticed that by placing a tourniquet at the thigh, the varicose veins collapsed when the patient was walking, except in case of deep veins impairment (Perthes Test).

Contrary to the dramatic occlusive effects of the femoral vein ligation, the varicose GSV ligation provided good outcomes, Trendelenburg suspected a "private circulation" where the superficial veins are drained back downwards into the deep veins through alternative pathways (perforators) thanks to the activity of muscle pumps.

A century later Claude Franceschi took over the hemodynamic approach and developed complementary concepts thanks to the Doppler Ultrasound vascular investigation that he pioneered and published in the very first book in the world in 1977[10] as well as the first vascular Ultrasound imaging book in 1986[11]. He studied fluid mechanics to understand his observations, which led him to propose an hemodynamic model of venous pathophysiology. Being an angiologist who faced the everyday need for vital GSV grafts to treat arterial and coronary diseases, he took the most of this model to design a GSV conservative treatment of venous insufficiency named CHIVA, published in 1988.

Over time, CHIVA was demonstrated better than the non-conservative methods by several reviews, randomized and controlled trials, and Cochrane Library reviews[12-17]. Nowadays, many options, conservative and ablative, are proposed to treat the primitive varicose veins of the lower extremities.

The conservative consists of medical compression or CHIVA strategy that is eligible in all the cases, while ASVAL is ablative of the GSV tributaries and GSV conservative only in selected cases because it is based on different hemodynamic concepts[18]. The non-conservatives are represented by various surgical or endovenous procedures.

Table I
CHIVA precursors who described the hemodynamic aspects of the venous insufficiency and its therapeutic consequences

Ambroise Paré 1509-1590: first GSV ligation at the middle height of the thigh.
Everard Home 1756-1832: causal relation between valve incompetence, excess of hydrostatic pressure and consequent leg ulcer healing by GSV ligation.
Tommaso Rima 1777-1843: hypothesis of a veins reflux refilling the varicose veins when standing up and the consequent effects of GSV ligation at the thigh.
Benjamin Collins Brodie 1783-1862: fluid dynamic explanation of Rima's hypothesis.
Friedrich Trendelenburg 1844-1924: hypothesis of a venous "private circulation" activated by walking.
Georg Clemens Perthes 1869-1927: confirmation of "private circulation" stopped by deep veins impairment.
Claude Franceschi 1988: hemodynamic approach of venous insufficiency. The CHIVA Strategy.

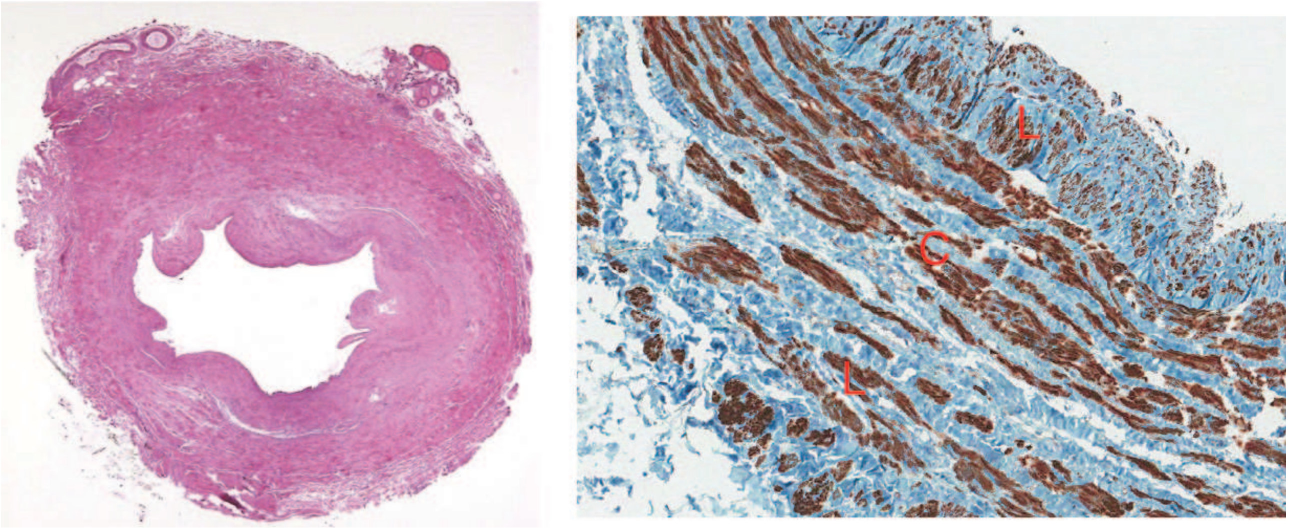

Figure 1 - Leg GSV Hystological specimen after CHIVA treatment. Hematoxylin and Eosin staining techinque on the left. Desmin immunohistochemistry staining technique on the right: smooth muscle cell in Brown. There is moderate intimal fibrosis, hypertrophy of the media and adventitia with vasa vasorum. Muscle fibers are well represented as a result of muscle work training. Three ordered layers of smooth muscle fibers: longitudinal on the intimal side, central circular, longitudinal on the adventitial side. Regular appearance of the endothelium of the intima layer. Normal hystoarchitecture.

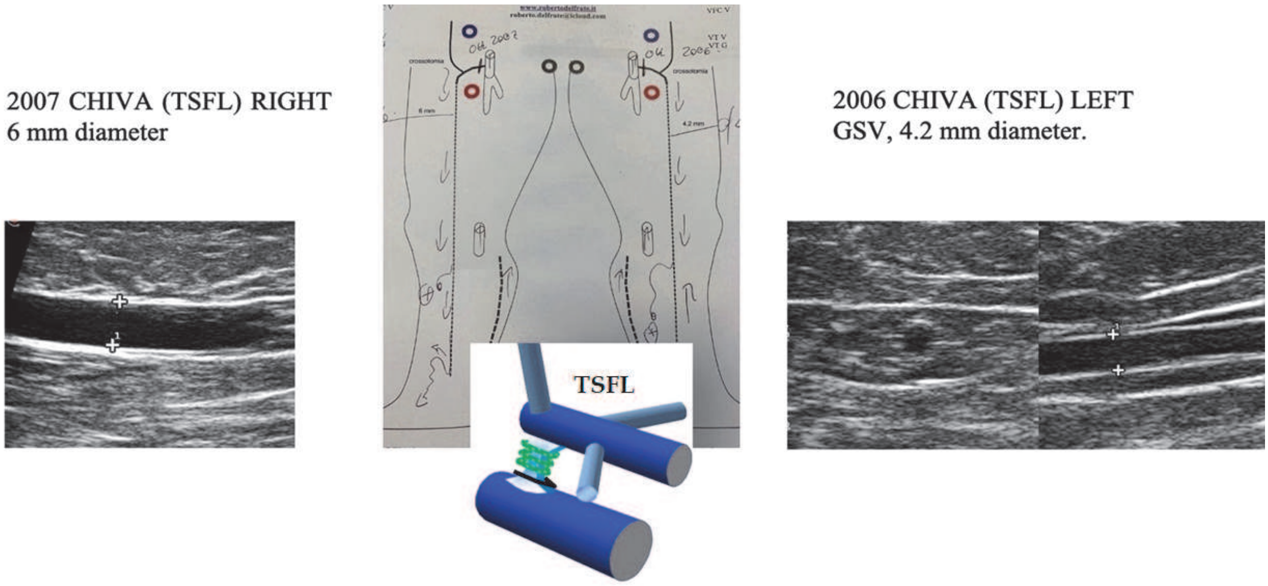

Figure 2 - B mode appearance of the thigh right and left GSV, 15 and 16 years after CHIVA 1 strategy: saphenous-femoral disconnection without arch section (TSFL:Triple Saphenous Femoral Ligation). GSV regular B-mode appearance. Right GSV 6 mm, left GSV 4.2 mm diameter at the upper third of the thigh.

The Great Saphenous Veins preservation

The GSV CHIVA conservation objective is dual: to restore its drainage function (whatever its flow direction) provided its pressure and flow content are normalized, sparing the GSV vein trunk for potential future bypass[1, 15, 16]. 2-3% of patients treated for varicose veins will need an arterial bypass[19-22] Some studies confirm the refluxing GSV eligibility for arterial bypass[22-23]. 70% of varicose patients had venous segments eligible for coronary bypass[24]. It is demonstrated that GSV homograft prevails over the post-stripping cryopreserved GSV allografts[25-27].

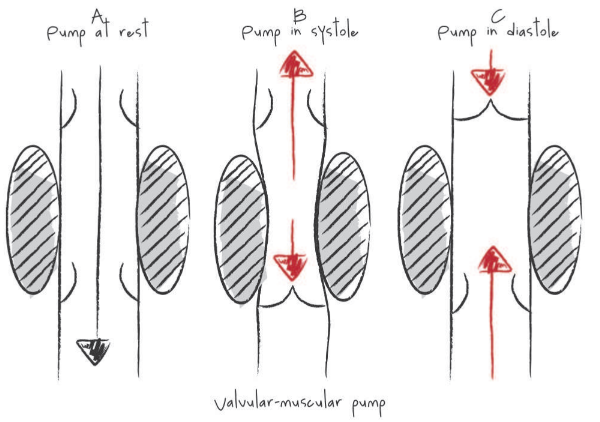

Figure 3 - valvulo-musclular pump and Dynamic Fractioning of the Gravitational Hydrostatic Pressure (DFGHP). Note the valves behavior.

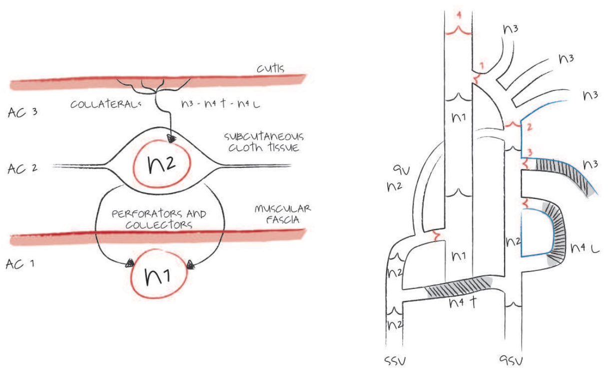

Figure 4 - anatomical-functional venous networks N1: in AC1 :sub-fascial deep veins. N2 in AC2. N2: Great and Small Saphenous veins, part of Anterior Saphenous, and Giacomini's vein intra-fascial pathway N3 and N4 in AC3. N3: Great and Small Saphenous tributaries and other epi-fascial veins. N4L: Longitudinal connecting veins between two different level saphenous zones. N4T: Transversal connecting veins between Great and small Saphenous veins. Drainage physiological hierarchy: N3>N2>N1, N3>N1 through junctions and perforators. 1 terminal valve, 2 preterminal valve, 3 cardinal valve.

Indeed, if GSV preservation is a condition for recurrence-rate reduction, is it also of great interest as a potential venous graft. In addition, histologic assessments were performed. The GSV is a propulsive vein, with a smooth muscular layer growing hyperplasic during life due to the workload that is daily subjected to[28]. This is also confirmed in the arterialized venous grafts in mice[29-30]. The histoarchitecture of segments of the post-CHIVA preserved GSV was normal (fig.1) with hyperplastic smooth muscular layer[31]. So, the preserved post-CHIVA GSV may be useful for lower limb or coronary bypasses if the B-mode appearance is, most of the time, regular (fig.2).

CHIVA Hemodynamic basis

The venous hemodynamics takes into account various venous pressure parameters[32-33].

Transmural Pressure: TMP is the pressure resulting from the intra-venous pressure IVP and the extra-venous pressure EVP opposition. So, it increases with the rise of IVP, decrease of EVP, and vice versa. IVP is composed of Residual Pressure (RP) provided by the arterial pressure through the micro-circulation resistance, Gravitational Hydrostatic Pressure (GHP) that varies with the vertical height of the venous blood column, and the Valvo-Muscular Pump Pressure (VMPP) provided by the Valvo-Muscular pumps (VMP). Gravitational Hydrostatic Pressure (GHP) and Dynamic Fractioning of the Gravitational Hydrostatic Pressure (DFGHP): in healthy individuals GHP varies with the vertical height of the blood column from the heart to the feet. So maximum in standing and minimum in horizontal position.

It decreases when walking because the VMP closes alternately the upstream and downstream valves during the systolic and diastolic phases (fig.3): DFGHP. So, DFGHP is impaired in proportion to the deep and/or superficial venous valve incompetence. Restoring it, is one of the aims of CHIVA. **Residual Pressure**: physiologically, RP is low and varies only with the resistance of the micro-circulation. It increases pathologically in case of a venous obstacle to the draining flow, right heart failure or intra-abdominal cava vein compression. So CHIVA prevents RP excess by preserving the veins patency.

Venous hierarchical drainage (fig.4): normally, the venous flow obeys a hierarchical drainage from the superficial to the deep venous network. N1 are all the deep veins below the muscular fascia; N2 are the saphenous axis veins (Great Saphenous Vein (GSV), Short Saphenous Vein (SSV), intra-fascial segment of the Anterior Accessory Saphenous Vein (AASV), and the Giacomini Vein (GV) located in inside the duplicate subcutaneous fascia above the muscular fascia (Egyptian eyes)[34-38].

N3 are the veins above the subcutaneous fascia. N4 veins interconnect different levels of the same N2 (N4L Longitudinal) or different N2 (N4T Transversal). The physiological drainage hierarchy is N3>N2>N1, N3>N1. The competent valves block the reflux triggered by any reverse, i.e cardio-fugal, pressure gradient PG (cough, Valsalva maneuver, diastolic phase of the VMP) so hampering the reversal of the hierarchical direction.

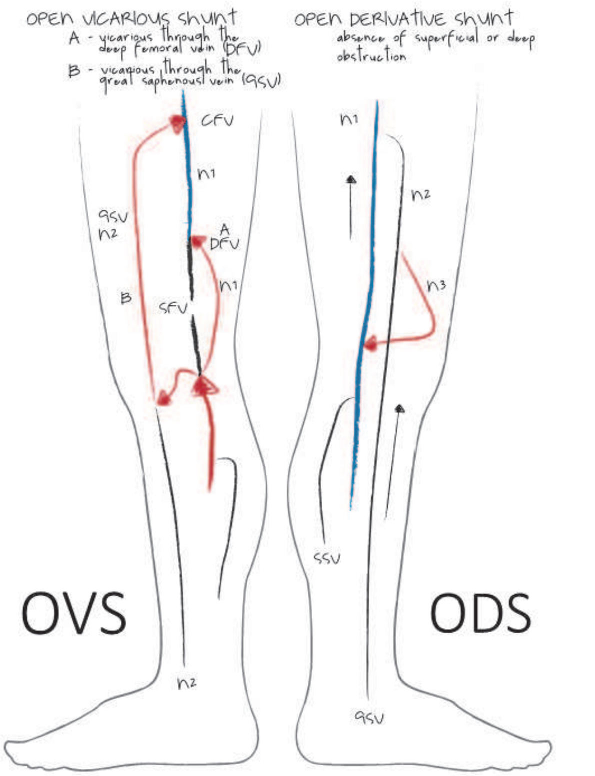

Figure 5 - OVS on the left. The flow enters the shunt due to the need for drainage in the presence of organic anatomical or functional obstruction or stenosis of the physiological venous drainage pathway. ODS on the right. Diastolic flow is not overloaded by any N1 flow, but only by N2.

In case of superficial valve incompetence, this hierarchy is reversed, i.e N1>N2>N3, N1>N3, N2>N3, during the Valsalva maneuver and/or the lower limbs VMP diastole. CHIVA restores the hierarchy N3>N2>N1, N3>N1. Notice that even if the flow direction of some of N2 or N3 segments is retrograde (reflux) it plays its physiological role provided it obeys the proper hierarchy.

Veno-venous shunts: a shunt is defined as a conduit connecting two points of a circuit that represent an additional pathway for the flow. Veno-venous shunts are veins overloaded by an additional flow provided by other veins. Their hemodynamic significance differs according to the feature of flow they divert from another vein. The place where the flow is diverted is called escape point EP and the distant place where it is restituted is called re-entry point RP. The blood that enters the shunt reverses the physiological hierarchy and adds its flow and pressure to the physiological drainage of the shunting vein. According to the type of the shunt, the overloading flow is activated at rest, during the systolic, diastolic or both phases of VMP.

The Open Vicarious Shunt (OVS) is a compensatory pathway activated at rest by the Residual Pressure and by the VMP systole (fig.5). The EP is N1>N2 or N1>N3 and it is activated by Paraná /Squeezing systole. RP is N3>N1 or N2>N1. It may be active at rest or only when evoked by a dynamic test. A dynamic obstacle exists and it bypasses it. Its rate of compensation effect is assessed by the Doppler measure of the Posterior Tibial Vein Pressure in a recumbent posture, at rest, and at stress[39-42]. These shunts are respected by CHIVA.

A **Closed Shunt (CS)** is always made of an N1>N2 or N1>N3 EP; there is only one exception represented by a variant of shunt 2a with N2-N4L escape point. It works like a closed circuit because part of the diastolic refluxing flow entering N1 is recycled through the EP in the same shunt by the successive VMP diastole (fig.6). So CS confirms the Trendelenburg intuition. CHIVA disconnection of N1> N2 or N1>N3 EP suppresses the overflow provided by N1.

Open Deviated Shunt (ODS) is never fed by N1>N2 nor N1>N3 EPs, but N2>N3, so its diastolic flow is not overloaded by any N1 flow but only by N2 (fig.5). So, there is no recirculation, just a diastolic deviation. CHIVA disconnection of N2>N3 EP suppresses the overflow provided by N2.

Mixed Shunt (MS) combines CS and OVS. Their common EP is N1>N2 or N1>N3 EP and their common proximal segment is N2 or N3 which shows consecutive systolic and diastolic refluxes. Their EP and proximal venous segment are common and their terminal segments diverge at the Separation Point (SP)[43, 44] towards distinct Re-entry Points (fig.6). So, there is only a Paraná/squeezing diastolic flow in the CS terminal segment and only a systolic flow in the terminal OVS segment. Consequently, CHIVA doesn't disconnect the common EP but only the terminal segment of the CS at the SP level.

Duplex US assessment and venous cartography

Duplex Ultrasound scanning is mandatory to perform an accurate venous anatomy-hemodynamic cartography because it is the key point of the strategy and tactics of the CHIVA treatment. The Echo Doppler of the lower limbs is performed using a 7-12 Mhz linear probe, Pulse Repetition Frequency (PRF) being adjusted between 0.75-1 kHz, capable of detecting even low-speed flow from 0.05-0.10m/sec. A convex probe of 3-7 Mhz is also necessary. Hemodynamic maneuvers must be used to activate the pumps.

Squeezing is the most common maneuver, and consists of manually squeezing and releasing the muscle pump of the venous collector being analyzed, i.e. not only the calf. The **Paraná** maneuver is preferable to the squeezing test because it activates more physiologically the VMP[45-47]. It consists of a slight push to the waist of the patient which triggers a calf proprioceptive contraction-relaxation reflex.

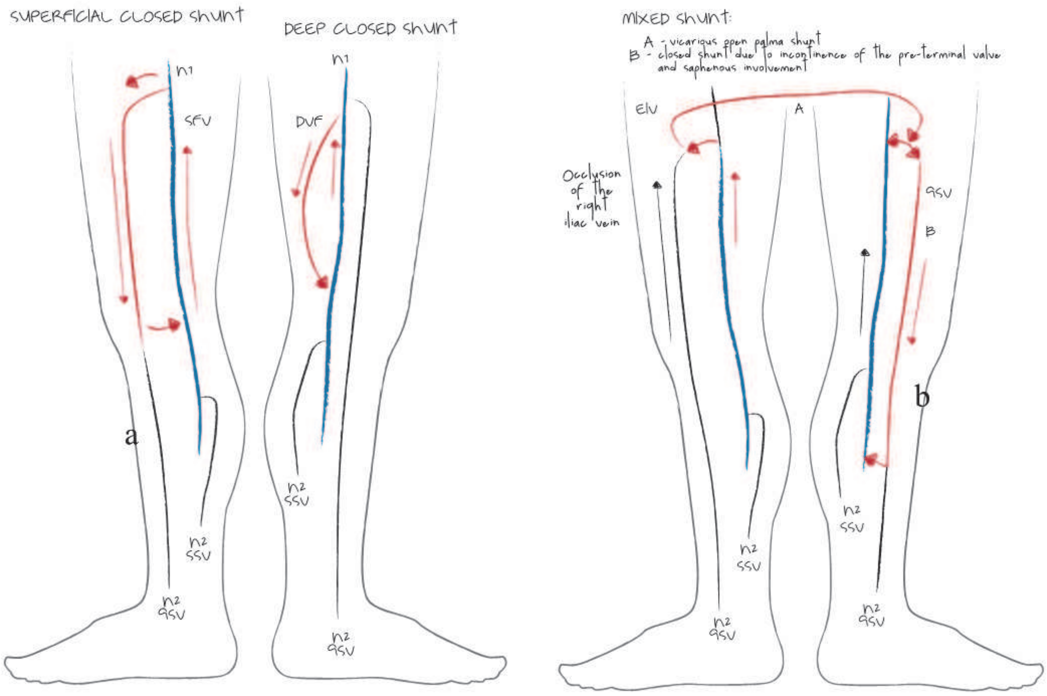

Figure 6 - Closed Shunt (a). It is a private circulation. Blood recirculates in a group of veins and is withdrawn from the general circulation. It can involve superficial veins but also only veins in the N1 district. Mixed Shunt (b). it combines a CS and an OVS.

The **Valsalva test** consists of a blocked and forced expiration that reverses downwards the Pressure Gradient. It stops the flow of the competent veins but it reverses it through N1>N2 and N1>N3 EPs. Notice that it triggers a reflux throughout N2 and N3 only if N1>N2 or N1>N3 junctions are incompetent. If N1>N2 or N1>N3 junctions are competent, it cannot trigger a N2 or N3 reflux neither in S0, even if these veins show a Paraná diastolic reflux.

The **Perthes maneuver** tests the effect of the eventual escape point disconnection on the varicose vein collapse as well as the quality of the RP.

Escape points

Pelvic Leak Points (PLP): PLPs are 7 at each side of the perineum and the pubis. They represent the N1>N3 refluxing perforators from the pelvic N1 down to N1>N3 EP where they feed 4 or 5 Shunts types (see below). Their VMP diastolic reflux must be confirmed by a Valsava reflux because the VPM reflux is not specific N1>N3 EP reflux. Their exceptional permanent reflux at rest attests to their compensatory role OVS of a pelvic N1 obstruction.

Three of them are fed by the parietal branches of the hypogastric vein. Female and male **Obturator Point (OP)** when the anterior muscular circumflex vein, the anterior branch of the Obturator Vein connects to the GSV at the groin.

Superior and Inferior Gluteal Points (SGP-IGP) when N3 Valsalva reflux is fed by the superior and inferior gluteal veins. Three additional PLPs, **Perineal Point (PP), Inguinal Point (IP), and Clitoris Point (CP)**, were described by Franceschi[48-51] They are particularly present in women who had one or more previous pregnancies, where they are responsible for an important rate of varicose veins. They represent the N1>N3 refluxing perforators from the visceral branches of the Hypogastric Vein.

The **PP** (Fig.7) is the posterior vulvar veins perforate the Perineal Superficial Fascia just underneath the posterior quarter of the vulva-perineal fold.

Table II
Clinical conditions associated with increased TMP

stenosis or obstruction of a venous segment or reflux with overload of a venous district
iatrogenic from drugs, or collapse of arteriolar resistances from FAV
preferential flow resulting from the angle of insertion of a perforator into a deep vein
functional stenosis from tendon lamination, or postural clamps
congenital absence of outflow pathways of malformative origin
intense muscular activity with increased arterial flow and consequent overloading of the venous pathways

TMP - trans-mural pressure

The **CP** (Fig.7)is the anastomotic plexus that connects the Internal Pudendal Vein, the Bulbar Vein, the Dorsal Clitoris Vein, and the External Pudendal Vein. The reflux can feed ipsilateral or contralateral perineal or anterior labial veins, the External Pudendal Vein, and then the GSV.

An **Intermediate Perineal Point (IPP)** also exists (Fig.7) and represents the hole of the Perineal Superficial Fascia through which the intermediate vulvar vein reaches the vulvar plexuses.

The **IP** (Fig.8) is the the superficial ring of the inguinal canal. It is fed by the refluxing vein of the **Uterus Round Ligament (URLV)**. The URLV reflux is most of the time fed by Gonadal veins reflux.

Male I Point (MIP): In the male, the gonadal vein, especially when refluxing (varicocele) may feed a reflux in the GSV directly or throughout the superficial epigastric veins. **Male C Point (MCP)**. Most rarely the GSV reflux is fed by the dorsal plexus of the penis which refluxes throughout an EP located at the subcutaneous fascia.

Notice that the PLP reflux can feed any N2 or N3 veins at any random level of the thigh and the leg and that an I, P, or C point reflux may cross the middle line and feed the varicose veins of the opposite limb. The impact of a female pelvic escape point on a varicose vein is significant. In personal experience, in the 8.3% of all the varicose veins treated, a pelvic escape point was disconnected (90% female, 10% male). Overlooked pelvic escape points may cause a relapse of varicose veins, especially chaotic in case of ablation of the GSV[52-55].

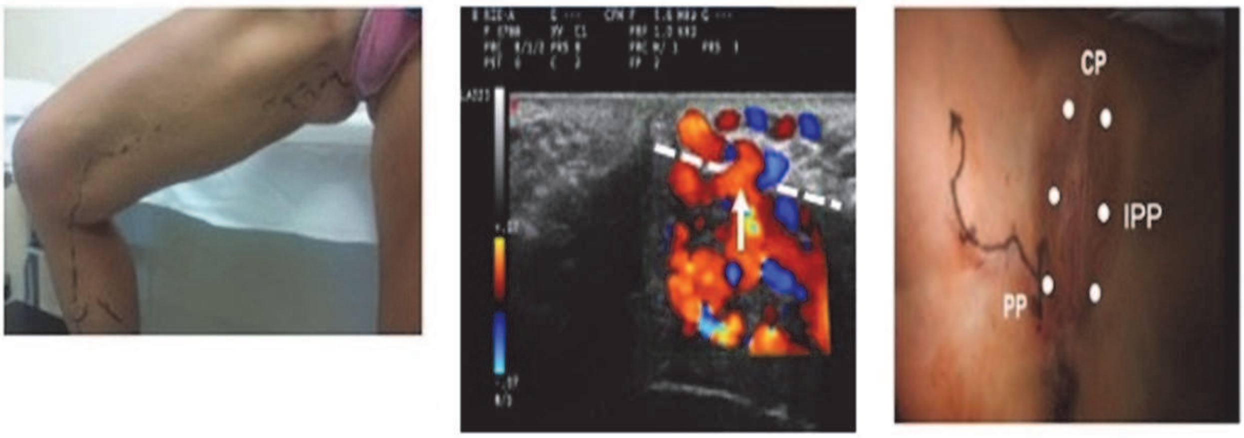

Figure 7 - On the left patient position for P points echo-duplex check. In the mid image of a PP: the white arrow shows the PP systolic Valsalva reflux, while the white dashed line represents the vulvar fascia. On the right are represented all the 6 perineal escape points: C, IPP, PP. The black line and arrow represent the varicose vein fed by the PP systolic Valsalva reflux

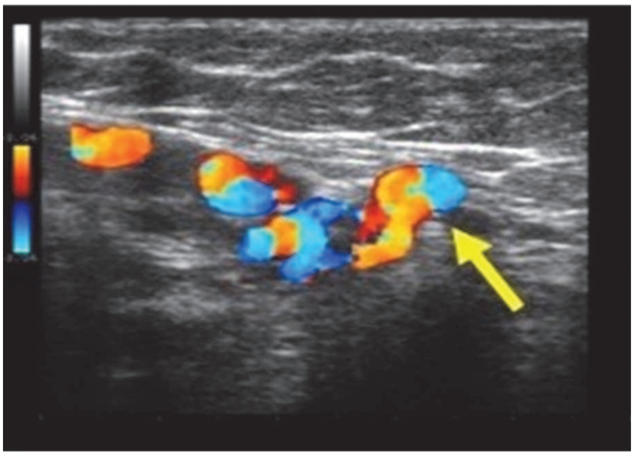

Figure 8 - Right IP. The systolic valsalva reflux is detectable in the round ligament venous plexus running into the inguinal canal from the internal ring and the medial subcutaneous ring (yellow arrow). The transversalis fascia and the fascia of the oblique external muscle are the hyperechoic lines detectable above and below the round ligament

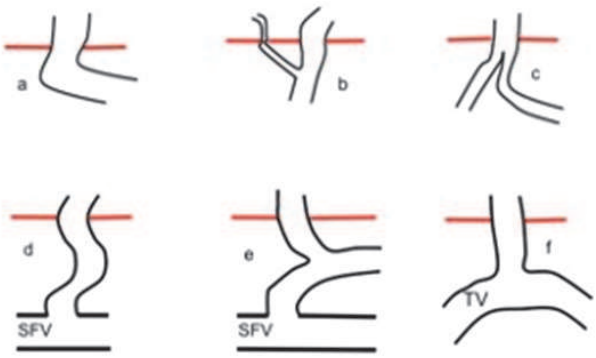

Figure 9 - Perforators appearance: linear straight appearance (a), upward branched (b), downward branched (c), direct confluence into a straight N1 collector generally the superficial femoral vein (d), confluence into a collateral of a main N1 collector generally the superficial femoral vein (e), confluence into an arch of an N1 collector generally a posterior tibial vein (f)

Saphenous femoral junction (SFJ): the SFJ is a strategic point where several different hemodynamic patterns may be misinterpreted. As a matter of fact, the N1>N2 reflux at the GSV end assessed by Paraná/squeezing is not specific of the incompetence of the terminal valve and must be every time confirmed by positive Valsalva. This reflux can be also due to a PLP. That is why Valsalva must check the arch tributaries. If it is positive, these tributaries are followed upwards until the Ep is detected. If Valsalva is negative, the Paraná reflux is just due to the incompetence of the pre-terminal valve below a competent terminal valve or a post-CHIVA disconnection SFJ (see below shunt 0). Notice that the physiologic flow of the arch tributaries may be evoked by Paraná/squeezing diastole, but it is always stopped by the Valsalva systole and released by the Valsalva diastole. When the SFJ is the EP of an OVS as Palma due to an iliac obstruction, it refluxes during the Paraná/squeezing systole. The reflux is successively systolic and diastolic in the case of Mixed Shunt (see below). It may also be an RP of the opposite SFJ EP.

Saphenous popliteal junction (SPJ): Its location is variable and the Saphenous popliteal junction may be not direct to the Popliteal vein but to a Gastrocnemian Vein. It is more subject to a Mixed Shunt because of constitutional stenosis of the Femoral Vein at the Hunter annulus.

Perforators: are interconnecting veins between the deep (N1/AC1) and superficial venous system above the muscular fascia (N2, N2, N4/AC2, AC3). Perforators must be differentiated from venous collectors, which on the contrary are permanently and normally visible, and represent a system of veins draining from the surface to the depths, forming an interconnecting system between the venous network of the abdominal wall, gluteus, and lower limbs and the pelvic venous plexuses. They are generally, though not exclusively, visible in the event of overloading of a venous path, with the functional purpose of redistributing flows and pressures. Perforators represent an emergency defensive system activated by an increase in PTM (Table 2). Regardless of the anatomical location[56, 57], different typologies of perforators exist according to their morphological appearance and confluence in N1 (Fig.9). From the anatomical and functional point of view, two different categories of perforators can be distinguished: direct (from the surface to an intermuscular vein) and indirect perforators (from the surface into an intramuscular vein). All the features just listed affect therapeutic strategy and clinical outcome. Normally flow goes from the surface to the deep through crosses, collectors, or perforating veins thanks to a favorable pressure gradient[58].

The foot is the only exception. The closure of their valves prevents reflux when the gradient is reversed. The pressure gradient is physiologically reversed during the systole of the lower limbs and thoracoabdominal pumps (coughing, defecation efforts, Valsalva maneuver). It is reversed pathologically at rest as well as during pump systole when run-off resistances increase and consequently also the residual pressure). The reflux always manifests the valve incontinence of the perforator, therefore a pathology of the perforator vein, but this valvular pathology does not always create pathogenic conditions (venous function impairment).

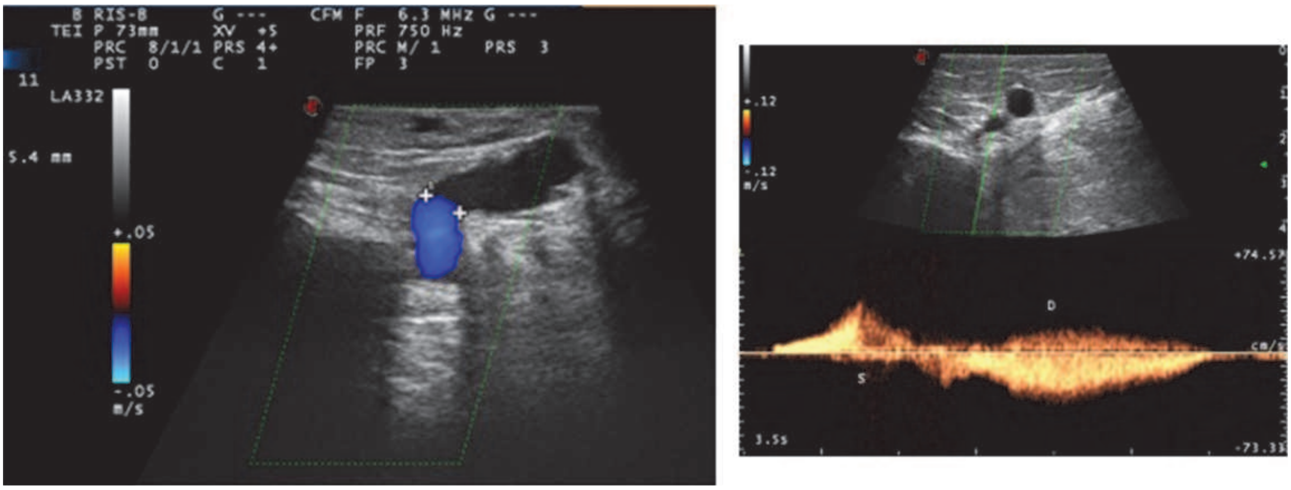

Figure 10 - on the left 5.4 mm. paratibial direct continent perforator; Paraná systolic and diastolic inward flow. It's a perfect re-entry point. On the right direct paratibial biphasic perforator: it's a re-entry point.

To correctly check perforator veins hemodynamic maneuvers are mandatory. Gravitational tests (static-squeezing, dynamic-Paraná) hypertensive test- Valsalva. The systole of the Valsalva maneuver increases N1 collectors pressure, highlighting every incompetent perforator anywhere in the lower limbs. Gravitational maneuvers highlight open vicarious shunts. Echoduplex is necessary for the evaluation of superficial as well as deep venous paths. The echo-duplex check looks for escape points, re-entry points, and venous paths, to identify a venous shunt and prepare the cartographic report. The ambulatory non-invasive deep pressure measurement, at rest on both sides or after muscle activation of the flow, is necessary too. It's necessary to understand if a perforator represents an escape point or a re-entry point as encoded by the CHIVA hemodynamic conservative strategy. A **re-entry point** is activated by the same conditions as the EP it is connected to, but it flows inwards instead of outwards. Most of the time it is represented by the perforators below the knee.

A reflux (upstream flow) through a perforator during muscle pump systole caused by manual compression of the calf or Parana maneuver is always an expression of a perforator pathology, but it may not be pathogenic in the absence of a deep obstruction if the diverted flow return downstream and continue towards the right heart: N1-N2-N1. The venous function is not impaired. The systolic reflux in a perforator vein during muscle pump contraction (gravitational tests) is pathological when it compensates for an obstacle in the deep allowing the outflow, and so tissue drainage. The systolic reflux of a perforator during the Valsalva maneuver is always pathological and pathogenic because it translates a reflux that continues in an inverted direction into the superficial network.

The systolic diverted flow continues in a retrograde superficial venous path until it reaches a re-entry perforator thanks to a diastolic favorable pressure gradient (diastolic pump aspiration). perforator reflux activated by the muscle pumps diastole (gravitational static and dynamic tests), associated or not with deep reflux, is always pathological and also pathogenic because it causes a flow contrary to the direction of tissue drainage and generates an overload of flow and venous pressure in the district. **Bi-Phasic perforator flow**: frequently, essentially below the knee, the inward re-entry inflow evoked by the Paraná/Squeezing diastole is preceded by a systolic outflow. The last one is of low hemodynamic relevance and is usually much less important than the inflow. Biphasic perforators may represent a re-entry point (Fig.10). Is the perforator diameter a suitable parameter to define a pathological and pathogenic perforator? In the AVF 2023 guidelines are considered pathologic the perforator veins with an outward flow duration ≥ 500 ms and a diameter ≥ 3.5 mm on DU[59].

In my personal experience, re-entry perforators are often dilated by the excess pressure and flow rate of the N2/N3 overloaded by one or more Escape Points (Fig.10). It's necessary to respect these re-entry perforators as they work to reduce the TMP. This analysis refers to the hemodynamic bases of venous pathophysiology confirmed by the results of the CHIVA treatment. For these reasons, the flow of perforators should be defined at rest, in systole and diastole of both the thoracoabdominal (Valsalva) and the muscle pump (dynamic/Paraná and static gravitational tests. Squeezing alone in a patient standing or sitting is not sufficient, and creates a risk of overtreatment.

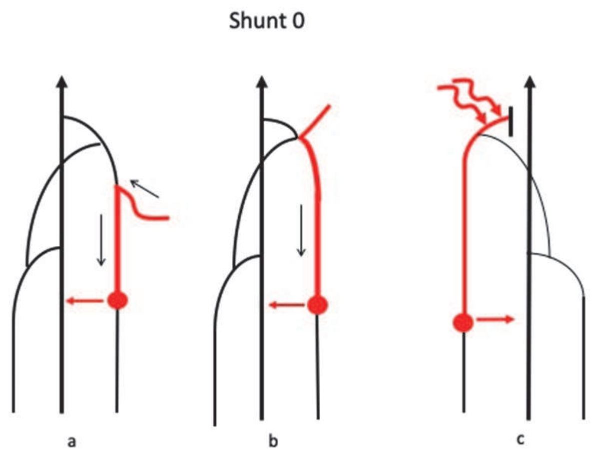

Figure 11 - Shunt 0. A segment of Saphenous vein with the retrograde flow in diastole, also intermittent (after muscular activation), arising from the inflow of a trunk or arch collateral (a,b), or post-CHIVA (c). Respected hierarchy of drainage.

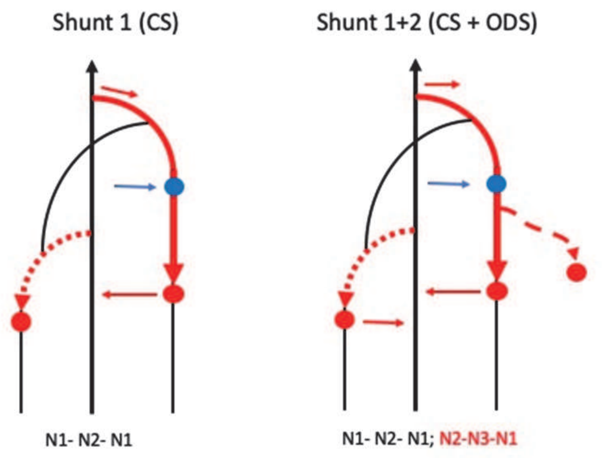

Figure 12 - Shunt 1 on the left. Escape Points: terminal valve SFJ (red continuous line), SPJ (red dotted line), N2 direct insufficient perforanting vein (blue line and blue circle). N1-N2-N1. Shunt 1 + 2 on the right: one or more Open Derivative (red dashed) Shunt(s) are added to shunt 1.

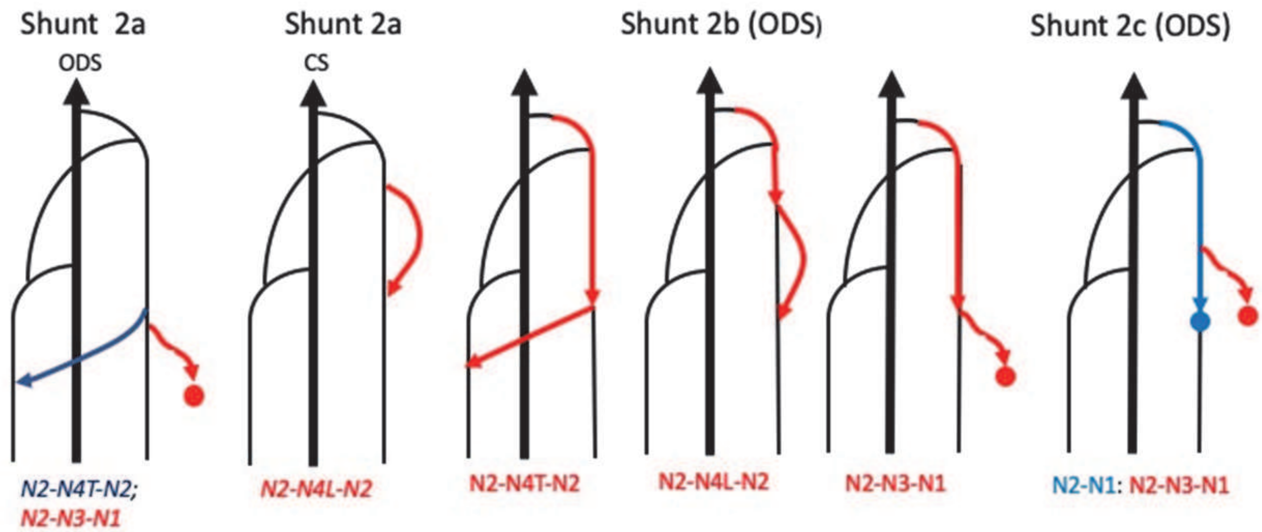

Figure 13 - Shunt 2a on the left side. Two distinct types of shunt 2a exist: ODS and CS (the only exception in shunts 2a. Only hydrostatic pressure increases in the ODS. There are no N2 segments with retrograde flow. Shunt 2b in the midle and Shunt 2c on the right.

Shunts

The following classification is consistent with what was established by the VII meeting of the European Chiva Association held in Teupitz in 2002 [60, 61] and coherent with the shunt classification originally reported by Claude Franceschi in 1988[1] and Jorge Juan Samsó in 2003[62].

Shunt 0 (Zero) is a harmless shunt (fig.11). It is a vein that fulfills its physiological role despite its retrograde flow (reflux) because it is not overloaded and respects the physiological hierarchy. It may be the case of any refluxing N2 or N3 veins in healthy people or after CHIVA disconnection of CS and ODS EPs because it leaves behind a no more overloaded flow. It is activated only by the

VMP diastole (Paraná/Squeezing) and not by the Valsalva systole. Notice that the alleged inflammatory role of oscillatory flow disappears after CHIVA even if retrograde. This is attested by a study regarding the inflammatory effect of oscillating flow[63].

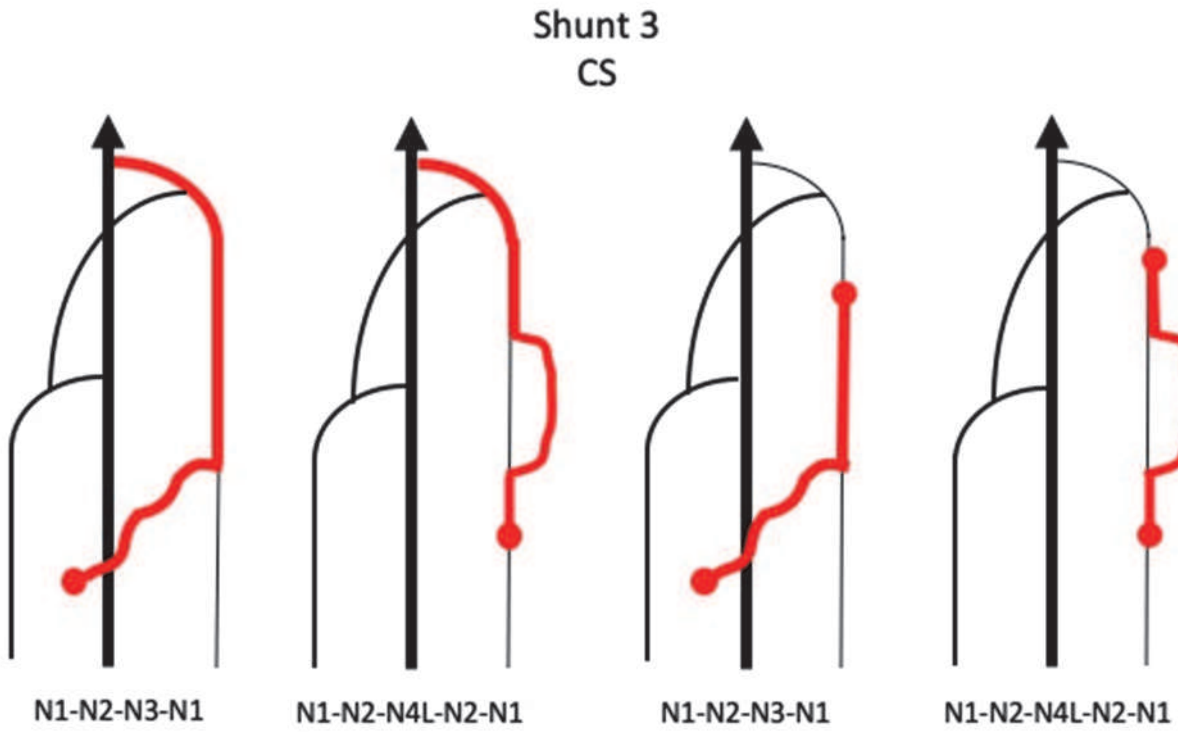

Figure 14 - Shunt 3. It's a closed shunt. Escape point N1-N2, with an N3 or N4 interposing itself between the escape point and the re-entry to bypass an N2 continent segment.

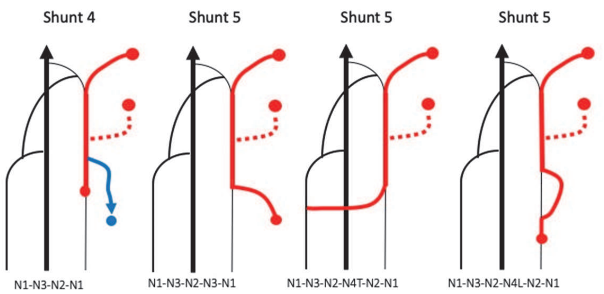

Figure 15 - Shunt 4 on the left: PLP red circle and continuous line, indirect perforator red circle and dashed line. A shunt type 2 (blue line and blue circle) can be associated with a shunt type 4: a direct re-entry on N2 and indirect re-entry through N3 exist. It's a shunt type 4+2. Different typologies of shunt 5 in the middle and on the right.

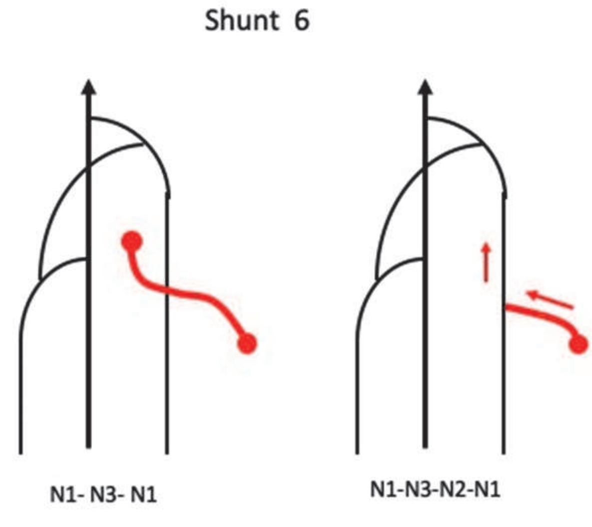

Figure 16 - Two possible typologies of shunt 6.

Shunt 1: CS. TransMural Pressure increases due to an increase in Hydrostatic Pressure and the addition of Shunt Pressure It shows an N1>N2>N1 reflux triggered by both Paraná/Squeezing diastole and Valsalva systole. Three different escape points (N1-N2) are possible: the terminal valve of the SFJ as well as the SPJ, or a direct perforation of N2 (Fig.12). RP may be multiple along N1 and the more distal one is called Terminal RP.

Shunt 2: it shows an N2>N3 or N2>N4L, or N2>N4T reflux triggered by Paraná/Squeezing diastole but not by Valsalva systole. Three different types of shunt 2 exist: 2A, 2B, and 2C (Fig.13). Two distinct types of shunt 2a exist: ODS and CS (the only exception in shunts 2a). Only hydrostatic pressure increases in the ODS. There are no N2 segments with retrograde flow. Shunt 2b is an Open Derivative Shunt (ODS) with proximal saphenous incontinence and a re-entry path exclusively through N3, N4L, N4T. Only hydrostatic pressure increases. Shunt 2c is an open derivative shunt (ODS) with proximal saphenous incontinence. Saphenous N2 re-entry point, without any interposition of continent N2 segment, and in addition through N3. Terminal valve continence, possible preterminal incontinence. Only hydrostatic pressure increases.

Shunt 1+2: CS. It's a shunt type 1 plus a shunt type 2 (Fig.12). It is a Shunt 2 connected to a Shunt 1. It shows an N1>N2>N1 + N2>N3 reflux triggered by both Paraná/Squeezing diastole and Valsalva systole. Notice that when the N1>N2 EP is disconnected, Valsalva doesn't evoke anymore a N2>N3 reflux. One or more Shunt 2s may connect to the Shunt 1. In a shunt 1+2 the main RP is on N2, while in the shunt 2+1 it's indirect.

Shunt 3: CS. N1>N2 reflux is evoked by both Paraná /squeezing diastole and Valsalva systole but N1 doesn't drain directly because intermediate RP is absent (Fig.14). So it drains into an incompetent N3 then directly or indirectly into a RP. Different types of shunt 3 may exist, with re-entry flow passing through an N4L/N4T to reach an N3-N1 re-entry point, or an N2. As sometimes the intermediate RP may be not seen whilst present, a re-entry test is possible. It consists in looking at the N2 flow when blocking N3 during a Paraná/squeezing maneuver or preferably Valsalva, particularly when the RP is searched at the thigh. TMP increases due to the presence of shunt pressure and increased hydrostatic pressure.

Shunt 4: CS. Its reflux is fed by N1>N3 EP (Perforator or Pelvic Point) then drains into N1 through a N2 segment: N1>N3>N2>N1 (Fig.15).

Shunt 5: CS. Its reflux is fed by N1>N3 EP (Pelvic or Perforator) then drains into N1 through a N1>N3>N2>N3>N1 (Fig.15).

Notice that most of the time EP in Shunt 4 and 5 is a pelvic leak point, and N1 most of the time refluxes in one or more of the descending tributary of the GSV arch (Superficial Epigastric Vein, External Pudendal, Epigastric Vein) and through the Obturator veins in the anterior medial circumflex muscular vein. As the physiological and the overloaded flow of Shunts 4 or 5 are both descending, Paraná and Squeezing evoke a descending flow when the GSV vein is incompetent irrespectively of its content i.e. only physiologic or overloaded by a pelvic leak. The only way to distinguish them is the systolic phase of the Valsava maneuver which stops the physiologic flow but increases the overloading flow.

Shunt 6: CS. Its Paraná/squeezing diastolic, Valsalva systolic N3 reflux (Fig. 16). It's fed by N1>N3 EP. The escape point is an indirect perforator draining into an N3 collector. Two different typologies of shunt 6 exist N1-N3-N1 (no involvement of N2), and N1-N3-N2-N1 (N2 doesn't show any refluxing segment).

When a **MS** combined with deep venous reflux and/or obstruction: whatever N1 damage and impairment, the VMP can in some cases still provide an efficient diastolic inflow. In that case, a satisfactory diastolic reflux in N2 and/or N3 and a Perthes test vein collapse confirm it. In that cases CHIVA disconnections can be performed. The absence of diastolic reflux and Perthes test collapse forbids any disconnection but doesn't identify the N1 damage. No diastolic reflux and small or absent systolic flow in a large varicose N2 (usually GSV trunk) is due to a **Deep Competitive Reflux (DCR)**. Dominant systolic flow attests to a OVS due to an N1 hemodynamical significant obstruction. In addition, a Doppler Venous Pressure measurement in a recumbent posture is possible to assess the hemodynamic significance of a possible deep venous obstruction.

Deep CHIVA[64]. I performed the disconnection of 3 Femoral veins and in addition 6 Posterior Tibial Veins ligations, 5 at the middle third of the leg and one posteriorly to the medial malleolus. Deep CHIVA is also possible. It regards the diagnosis and treatment of the deep venous closed shunts. It obeys the same hemodynamic principles as CHIVA. Most of the time applied in Post-Thrombotic Syndrome (PTS).

Post CHIVA Duplex US assessment: the disconnected veins are checked: patency, caliber, Paraná / Squeezing, and Valsalva maneuvers. Most of all the previously treated refluxing veins show normally a retrograde flow triggered by Paraná/Squeezing maneuvers because they are Shunts 0. Positive Valsalva is due to an N1>N2 or N1>N3 reflux recurrence or not treated (incomplete CHIVA procedure). As N2>N3 EPs are not activated by Valsalva, N2>N3 connections must be checked.

Cartography and Mapping: cartography is a schematic drawing of a venous network that reports the flow direction and the related shunts of each specific individual configuration to tailor as well the strategy and the tactics of the eventual CHIVA treatment. Then waterproof echo-guided signs are drawn on the skin at the very points to be treated.

Treatment

CHIVA is eligible in any case of superficial venous insufficiency of the lower extremities. The CHIVA strategy is also applicable in deep venous insufficiency to disconnect closed shunts for treatment of ulcers resistant to non-invasive therapy.

Strategy

The CHIVA strategy aims at the TMP restoration, the prevention of the varicose recurrence and the preservation of the eventual venous grafts by :

- Gravitational hydrostatic pressure fractionation
- Closed and Open Deviated Shunt disconnection
- Veins and Re-entry Perforators preservation
- Open vicarious shunt preservation
- GSV preservation for eventual bypass need

Shunts 1, 2, 4, 5, 6 are disconnected in one stage.

Shunts 3 and mixed shunts are subject to peculiar strategies.

In shunt 3 the intermediate N2 re-entry perforator is absent. So the simultaneous N1>N2 and N2>N3 disconnection would leave behind a thrombosed GSV trunk because no more drained. To avoid it, two strategies are proposed. The first one consists of a two steps procedure. The first step disconnects the N2>N3 Eps that restores the GSV antegrade flow[65, 66] but is rarely sustainable because it leaves behind a high GHP column which causes a redo N1>N2 reflux due to secondary RP opening. So, in that case, a second step disconnects later the N1>N2 (SFJ) when the reflux recurs. The second strategy is preferable when possible, i.e. when the competent GSV trunk below the N2>N3 EP is present and not hypoplastic. It consists of the devalvulation[51] of the competent segment of the trunk so that it allows reflux down to a lower RP perforator. Usually, this procedure is followed by a transient thrombosis and then a complete restore of the GSV trunk.

In mixed shunts, the common escape point is not disconnected but only the distal segment that diverges towards the CS RP. In Shunts 4 and 5, the disconnection of the PLPs can be done without any prior pelvic endovenous procedures in the absence of true Pelvic Compression symptoms without significant recurrence[39].

Tactics

Most of the time the incision is cosmetic short under local anesthesia (fig 11). All sutures are non-absorbable to avoid any redo to angiogenesis caused by inflammatory consumption of the thread. The disconnections should avoid leaving behind any stump. The N2>N3 disconnection is a division-ligation of N3 flush N2 with 2 to 3 cms phlebectomy. The PLP disconnections are division ligation + fascia suture procedures.

SFJ disconnection is performed flush the Common Femoral vein completed with a clip at the very SFJ. The disconnection consists of Crossotomy instead of Crossectomy because preserves the arch tributaries to prevent cavernomatous recanalization[67]. To reduce the risk of bleeding in an ambulatory operation, a peculiar Triple Sapheno-Femoral Ligation (TSFL) was proposed[68].

In the case of Short Saphenous vein reflux, the SPJ disconnection is most of the time performed below the Giacomini vein junction[69-71] and always in case of mixed shunt; the muscle fascia must be properly sutured with non-absorbable thread. Light compression + 12 days of preventive anticoagulation are prescribed.

Outcomes

Many studies were done for 30 years over the world. All of them showed the non-inferiority of CHIVA vs other Open surgery or endovenous methods. Moreover, RCTs[12-15] and Cochrane reviews[16-17] CHIVA vs Stripping, CHIVA vs Laser, CHIVA vs all the other methods attest to the CHIVA prevailing in terms of satisfactory clinical outcomes. recurrence and complications[72-74]. The clinical relief of the symptoms is followed by a progressive cure of the signs such as varicose veins complete collapse, skin damage and ulcers.

True CHIVA or Pseudo CHIVA

Nowadays several studies certify the reliability of the CHIVA strategy for the treatment of CVI: starting from the first pioneering EBM[12-15], to the Cochrane review in 2015[16-17] and other recently published papers[73-74]. But CHIVA needs a learning curve to avoid “bad CHIVA” procedures due to the lack of correct hemodynamic evaluation and cartography, as any other strategy or technique of surgery. CHIVA performed by experts is better than stripping, but good stripping is better than bad CHIVA performed by non-experts[75]. CHIVA is a complex approach, and high-level training and experience are needed to attain the results presented in RCT. Venous specialists require considerable education and determination to learn this approach. The best results are achieved if the same specialist can carry out both the hemodynamic and cartography phases and the surgical procedure. Otherwise, teama composed of a hemodynamic echo-duplex specialist and a surgeon is required. In this latter case, the surgeon must attend the fundamental phase of preoperative cartography to eliminate every possible mistake during surgery. To conclude, to increase the quality of the surgical application of the cartographic strategy, it is possible to perform an intra-operative b-mode or echo-duplex evaluation if the safety or accuracy of the procedure requires it.

Conclusion

CHIVA could look reluctant because of its steep learning curve. Yet, it is easy for those who have learned the hemodynamic basis and trained beside a mentor. The satisfaction doesn't regard only the good clinical outcomes of a low-cost and mini-invasive surgery, but also the chance offered to the patient for a future potential vital necessity of a venous graft.

References

1) Franceschi C. Théorie et pratique de la cure conservatrice et hémodynamique de l'insuffisance veineuse en ambulatoire [Theory and practice of conservative and haemodynamic treatment of venous insufficiency in outpatients]. Précy-sous-Thil France Editions de l'Armançon 1988.

2) Franceschi C. The conservative and hemodynamic treatment of ambulatory venous insufficiency. Phlebologie. 1989 Nov-dec;42(4):567-8

3) Franceschi C. Ambulatory and hemodynamic treatment of venous insufficiency (CHIVA cure). J Mal Vasc. 1992;17(4):291-300

4) Taylor GI, Palmer JH. The vascular territories (angiosomes) of the body: experimental studies and clinical applications. Br J Plast Surg. 1990;40:113-141

5) Taylor G I, Doyle M, McCarten G. The Doppler probe for planning flaps: anatomical study and clinical applications. Br J Plast Surg. 1990;43:1-16

6) Taylor GI, Caddy CM, Watterson PA, Crock JG. The venous territories (venosomes) of the human body: experimental study and clinical implications. Plast Reconstr Surg. 1990 Aug;86(2):185-213. doi: 10.1097/00006534-199008000-00001.

7) Tessari L. Histoire des evéinages: des origines au dèbut du XXe siècle [History of venous surgery: from the origins to the beginning of the 20th Century]. Phlebologie. 2000;53(2):259-65

8) Brodie B. Lectures illustrative of various subjects in Pathology and Surgery. By Sir B. C. Brodie, Bart., F.R.S., Serjeant-Surgeon to the Queen, &c. London: Longman & Co., 1846. Lecture VIII and IX, On Varicose Veins and Ulcers of the Leg. Pages 157-191. Available from https://archive.org/details/b21922810/page/n7/mode/2up?view=theater

9) Trendelemburg F. Über die Unterbindung der Vena saphena magna bei unterschenkel unterschenkel varicen [About the ligation of the great saphenous vein in lower leg varicose veins]. Beiträge zur klinischen Chirurgie. 1890;7:195-204

10) Franceschi C. L'Investigation vasculaire par ultrasonographie Doppler [Vascular investigation by Doppler ultrasonography]. Masson Ed, Paris 1977

11) Franceschi C, Franco G, Luizy F, Tanitte M. Précis d'echotomographie vasculaire. [Manual of vascular echotomography] Vigot Ed, Paris, 1986

12) Carandina S, Mari C, De Palma M, Marcellino MG, Cisno C, Legnaro A, Liboni A, Zamboni P. Varicose vein stripping vs haemodynamic correction (CHIVA): a long term randomised trial. Eur J Vasc Endovasc Surg. 2008 Feb;35(2):230-7. doi: 10.1016/j.ejvs.2007.09.011

13) Parés JO, Juan J, Tellez R, Mata A, Moreno C, Quer FX, et al. Varicose vein surgery: stripping versus the CHIVA Method: a randomized controlled trial. Annals of Surgery. 2010;251(4):624–31.

14) Iborra-Ortega E, Barjau-Urrea E, Vila-Coll R, Ballon-Carazas H, Cairols-Castellote MA. Comparative study of two surgical techniques in the treatment of varicose veins of the lower extremities: results after five years of followup. Angiología. 2006;58(6):459–68.

15) Zamboni P, Cisno C, Marchetti F, Mazza P, Fogato L, Carandina S, De Palma M, Liboni A. Minimally invasive surgical management of primary venous ulcers vs. compression treatment: a randomized clinical trial. Eur J Vasc Endovasc Surg. 2003 Apr;25(4):313-8. doi: 10.1053/ejvs.2002.1871. Erratum in: Eur J Vasc Endovasc Surg. 2003 Sep;26(3):337-8.

16) Bellmunt-Montoya S, Escribano JM, Dilme J, Martinez-Zapata MJ. CHIVA method for the treatment of chronic venous insufficiency. Cochrane Database of Systematic Reviews 2015 Issue 6. Art. No.: CD009648. doi: 10.1002/14651858.cd009648.pub3.

17) Bellmunt-Montoya S, Escribano JM, Pantoja Bustillos PE, Tello-Díaz C, Martinez-Zapata MJ. CHIVA method for the treatment of chronic venous insufficiency. Cochrane Database of Systematic Reviews 2021, Issue 9. Art. No.: CD009648. doi: 10.1002/14651858.CD009648.pub4.

18) Chastanet S, Pittaluga P. Ten-Year Outcomes of Treatment of Varicose Veins by Ambulatory Selective Ablation of Varices Under Local Anesthesia (ASVAL). J Vasc Surg Venous and Lymphatic Disorders. March 2018;6(2):289

19) Papakonstantinou NA, Baikoussis NG, Goudevenos J, Papadopoulos G, Apostolakis E. No touch technique of saphenous vein harvesting: Is great graft patency rate provided? E. J Thorac Cardiovasc Surg. 2015 Oct;150(4):880-8

20) Samano N, Geijer H, Liden M, Fremes S, Bodin L, Souza D. The no-touch saphenous vein for coronary artery bypass grafting maintains a patency, after 16 years, comparable to the left internal thoracic artery: a randomized trial. J Thorac Cardiovasc Surg. 2015 Oct;150(4):880-8. doi: 10.1016/j.jtcvs.2015.07.027. ClinicalTrials.gov NCT01686100. Ninos Samano, Örebro County Council, 2012.

21) Twine CP, McLain AD. Graft type for femoro-popliteal bypass surgery. Cochrane Database of Systematic Reviews 2010, Issue 5. Art. No.: CD001487. Updated version by Ambler GK, Twine CP. 2018, Issue 2. Art. No.: CD001487. doi: 10.1002/14651858.CD001487.pub3

22) Moritz A, Grabenwöger F, Raderer F, Ptakovsky H, Magometschnigg H, Ullrich R, Staudacher M. Use of varicose veins as arterial bypass grafts. Cardiovasc Surg. 1993 Oct;1(5):508-12.

23) Lofgren EP. In Bergan JJ, Yao JST (eds). Surgery of the veins 1985, 285-299.

24) Cohn JD, Korver KF. Selection of saphenous vein conduit in varicose vein disease. Ann Thorac Surg. 2006 Apr;81(4):1269-74

25) Streichenberger R, Barjoud H, Adeleine P, Larese A, Nemoz C, Chatelard P, Nedey C, Sabben. Allogreffes veineuses conservées à 4°C dans les pontages sousinguinaux: résultats à long terme dans 170 cas. [Venous allografts stored at 4°C for the infrainguinal bypass: long term results in 170 cases] Ann Chir Vasc. 2000;14:553-60.

26) Masmejan S, Deslarzes-Dubuis C, Petitprez S, Longchamp A, Haller C2, Saucy F, Corpataux JM, Déglise S. Ten Year Experience of Using Cryopreserved Arterial Allografts for Distal Bypass in Critical Limb Ischaemia. Eur J Vasc Endovasc Surg. 2019 Jun;57(6):823-31

27) Ziza V, Canaud L, Gandet T, Molinari N, Alonso W, Chastan R, Branchereau P, Picard E. Outcomes of cold-stored venous allograft for below-knee bypasses in patients with critical limb ischemia. J Vasc Surg. 2015 Oct;62(4):974-83

28) Chiarugi G, Bucciante L. Istituzioni di anatomia dell'uomo [Institutions of human anatomy]. Francesco Vallardi ed. XI edition. 1975, vol 2, chapter 12

29) Kwei S, Stavrakis G, Takahas M, Taylor G, Folkman MJ, Gimbrone MA Jr, García-Cardeña G. Early adaptive responses of the vascular wall during venous arterialization in mice. Am J Pathol. 2004 Jan;164(1):81-9. doi: 10.1016/S0002-9440(10)63099-4.

30) Westerband A1, Crouse D, Richter LC, Aguirre ML, Wixon CC, James DC, Mills JL, Hunter GC, Heimark RL. Vein adaptation to arterialization in an experimental model. J Vasc Surg. 2001 Mar;33(3):561-9

31) Delfrate R. Thanks to the CHIVA strategy, may the histoarchitecture of great saphenous vein-sparing, make it suitable as graft for bypasses? Veins and Lymphatics. 2019;8(1). doi: 10.4081/vl.2019.8227

32) Franceschi C, Zamboni P. Principles of venous hemodynamics. Hauppage, NY: Nova Science Publisher. 2009

33) Franceschi C. Dynamic Fractionizing, of Hydrostatic Pressure, Closed and Open Shunts, Vicarious Varicose Evolution: Have these concepts made the treatment of varices evolve? Phlebologie. 2003;56(1):61-66

34) Delfrate R, Grilli N. A new diagnostic approach to varicose veins: haemodynamic evaluation and treatment. Lorena Dioni Publisher. 2014 ISBN 978-88-98-681-00-6

35) Passariello F, Carbone R. Anatomia ecografica normale e patologica. In Passariello F (Editor) "La Chirurgia della Vena Safena Esterna". [Surgery of the shorter saphenous vein] pp 28-29. Napoli, New Print, 1991.

36) Bailly MJ. La cure hémodynamique de l'insuffisance veineuse en ambulatoire (CHIVA). [Hemodynamic cure of venous insufficiency in outpatients (CHIVA)] Journal de maladies vasculaires. 1992;17:241-9.

37) Bailly MJ. Cartographie CHIVA. Encycl. Med. Chir. (Paris, France). Techniques chirurgicales - Chirurgie vasculaire. 43-161-B, 1995, 4p.

38) Caggiati A. The saphenous venous compartments. Surg Radiol Anat. 1999;21(1):29-3.

39) Zamboni P, Portaluppi F, Marcellino MG, Manfredini R, Pisano L, Liboni A. Ultrasonographic assessment of ambulatory venous pressure in superficial venous incompetence. J Vasc Surg. 1997b;26(5):796–802

40) Norris CS, Beyran A, Barnes RW. Quantitative photoplethysmography in chronic venous insufficiency: a new method of noninvasive estimation of ambulatory venous pressure. Surgery. 1983;94:758–64.

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

42) Bartolo M. Antignani PL, Nicosia PM, Todini AR. Noninvasive venous pressure measurement and its validation. Int Angiol. 1988;7:182-89

43) Passariello F. The systo-diastolic reflux. JTAVR 2019;4(3). doi: 10.24019/jtavr.37

44) The Systo-Diastolic Event (Oct-Nov, 2012). A Vasculab Debate. doi: 2012.SYSTODIASTOLIC http://www.vasculab.it/systodiastolic.xml

45) Passariello F, Cappelli M, Ermini S. The Vasculab Manoeuvre: Simulating walking in venous investigations. Reviews in Vascular Medicine. 2016 Sep;6–7:20–8. doi 10.1016/j.rvm.2016.08.002

46) Ermini S, Passariello F, Cappelli M, Franceschi C. Experimental validation of the Paraná manoeuvre compared to the squeezing test. Journal of Theoretical and Applied Vascular Research. 2017 Dec 31;2(2):97–105. doi: 10.24019/jtavr.42

47) Franceschi C. Mesures et interprétation des flux veineux lors des manœuvres de stimulation. Compressions manuelles et manœuvre de Paraná. Indice dynamique de reflux (IDR) et Indice de Psatakis. [Measures and interpretation of venous flow in stress tests. Manual compression and Paraná manoeuvre. Dynamic reflux index and Psatakis index] J Mal Vasc. 1997 May; 22(2):91-5.

48) Delfrate R. Anatomy of Pelvic leak points in the context of varicose veins. Phlebologie. 2021 Jan 18;50(1):42–50. doi: 10.1055/a-1309-096

49) Franceschi C, Bahnini A. Points de fuite pelviens viscéraux et varices des membres inférieurs [Pelvic visceral leak points and varicose veins of the lower limbs] Phlébologie. 2004;57:37-42

50) Franceschi C, Bahnini A. Treatment of lower extremity venous insufficiency due to pelvic leak points in women Ann Vasc Surg. 2005;19:284-288

51) Franceschi C. Anatomie fonctionnelle et diagnostic des points de fuite bulboclitoridiens chez la femme (point C) [Functional anatomy and diagnosis of bulboclitoral leak points in women (C point)]. J Mal Vasc. 2008;33:42

52) Jiang P, Van Rij AM, Christie RA, Hill GB, Thomson IA. Non-saphenofemoral Venous Reflux in the Groin in Patients with Varicose Veins. Eur J Vasc Endovasc Surg. 2001;21:550-557

53) García-Gimeno M, Rodríguez-Camarero S, Tagarro-Villalba S, Ramalle-Gomara E, González-González E, González Arranz MA, López García D, Vaquero Puerta C. Duplex mapping of 2036 primary varicose veins. J Vasc Surg. 2009;49:681-689

54) Delfrate R, Bricchi M, Franceschi C. Minimally-invasive procedure for pelvic leak points in women. Veins and Lymphatics. 2019;8(1). doi: 10.4081/vl.2019.7789

55) Zamboni P, Mendoza E, Gianesini S. Saphenous vein-sparing strategies in Chronic Venous Diseases. Springer. Chapter 8 Delfrate, Mendoza. 2018. ISBN 978-3-319-70638-2

56) Caggiati A, Bergan JJ, Gloviczki P, Eklof B, Allegra C, Partsch H. International Interdisciplinary Consensus Committee on Venous Anatomical Terminology. Nomenclature of the veins of the lower limb: extensions, refinements, and clinical application. J Vasc Surg. 2005 Apr;41(4):719-24. doi: 10.1016/j.jvs.2005.01.018.

57) Cavezzi A, Labropoulos N, Partsch H, Ricci S, Caggiati A, Myers K, Nicolaides A, Smith PC. Duplex ultrasound investigation of the veins in chronic venous disease of the lower limbs--UIP consensus document. Part II. Anatomy. Eur J Vasc Endovasc Surg. 2006 Mar;31(3):288-99. doi: 10.1016/j.ejvs.2005.07.020.

58) Lee BB, Nicolaides AN, Myers K, Meissner M, Kalodiki E, Allegra C, Antignani PL, Bækgaard N, Beach K, Belcaro G, Black S, Blomgren L, Bouskela E, Cappelli M, Caprini J, Carpentier P, Cavezzi A, Chastanet S, Christenson JT, Christopoulos D, Clarke H, Davies A, Demaeseneer M, Eklöf B, Ermini S, Fernández F, Franceschi C, Gasparis A, Geroulakos G, Gianesini S, Giannoukas A, Gloviczki P, Huang Y, Ibegbuna V, Kakkos SK, Kistner R, Kölbel T, Kurstjens RL, Labropoulos N, Laredo J, Lattimer CR, Lugli M, Lurie F, Maleti O, Markovic J, Mendoza E, Monedero JL, Moneta G, Moore H, Morrison N, Mosti G, Nelzén O, Obermayer A, Ogawa T, Parsi K, Partsch H, Passariello F, Perrin ML, Pittaluga P, Raju S, Ricci S, Rosales A, Scuderi A, Slagsvold CE, Thurin A, Urbanek T, M VAN Rij A, Vasquez M, Wittens CH, Zamboni P, Zimmet S, Ezpeleta SZ. Venous hemodynamic changes in lower limb venous disease: the UIP consensus according to scientific evidence. Int Angiol. 2016 Jun;35(3):236-352.

59) Gloviczki P, Lawrence PF, Wasan SM, Meissner MH, Almeida J, Brown KR, Bush RL, Di Iorio M, Fish J, Fukaya E, Gloviczki ML, Hingorani A, Jayaraj A, Kolluri R, Murad MH, Obi AT, Ozsvath KJ, Singh MJ, Vayuvegula S, Welch HJ. The 2022 Society for Vascular Surgery, American Venous Forum, and American Vein and Lymphatic Society clinical practice guidelines for the management of varicose veins of the lower extremities. Part I. Duplex Scanning and Treatment of Superficial Truncal Reflux: Endorsed by the Society for Vascular Medicine and the International Union of Phlebology. J Vasc Surg Venous Lymphat Disord. 2023 Mar;11(2):231-261.e6. doi: 10.1016/j.jvsv.2022.09.004.

60) Criado E, Juan J, Fontcuberta J, Escribano JM. Haemodynamic surgery for varicose veins: rationale, and anatomic and haemodynamic basis. Phlebology: The Journal of Venous Disease. 2003 Dec 1;18(4):158–66

61) Yun S, Hwang M-O. The Teupitz Shunt Classification for CHIVA Strategy. Annals of Phlebology. 2023 Jun 30;21(1):1–4

62) Juan-Samsó J, Escribano-Ferrer JM, Rodríguez-Mori A, Bofill-Brossa R, Matas-Docampo M. Cirugía hemodinámica venosa en el tratamiento del síndrome varicoso [Hemodynamic venous surgery in the treatment of varicose syndrome]. Angiología. 2003;55(5):460-75.

63) Tisato G, Zauli G, Gianesini S, Menegatti E, Brunelli L, Manfredini R, Zamboni P, Secchiero P. Modulation of Circulating Cytokine-Chemokine Profile in Patients Affected by Chronic Venous Insufficiency Undergoing Surgical Hemodynamic Correction. Journal of Immunology Research. 2014 Mar 25;2-10 doi: 10.1155/2014/473765

64) Franceschi C.: Hémodynamique de la maladie postphlébitique: conséquences diagnostiques et thérapeutiques. [Hemodynamics of post-thrombotic disease: diagnostic and therapeutic consequences] Journal des Maladies Vasculaires. 2008 Mar;33:S5.

65) Passariello F. Suppression of the sapheno-femoral reflux by pure non-saphenous phlebectomy and anatomical structure of the reflux. Acta Phlebol. 2008;9:105-7

66) Passariello F. GSV calibre reduction and reflux elimination by tributaries disconnection: evidences and hypotheses. Acta Phlebol. 2013;14:25-30

67) Cappelli M, Molino-Lova R, Giangrandi I, Ermini S, Gianesini S. Ligation of the saphenofemoral junction tributaries as risk factor for groin recurrence. J Vasc Surg Venous Lymphat Disord. 2018 Mar;6(2):224-229. doi: 10.1016/j.jvsv.2017.09.005.

68) Delfrate R, Bricchi M, Franceschi C, Goldoni M. Multiple ligation of the proximal greater saphenous vein in the CHIVA treatment of primary varicose veins. Veins and Lymphatics. 2014;3(1). doi: 10.4081/vl.2014.1919

69) Passariello F, Carbone R. Nuove strategie per la Chirurgia della Safena Esterna. [New strategies for the surgery of the shorter saphenous vein] In Passariello F (Editor) "La Chirurgia della Vena Safena Esterna". [Surgery of the shorter saphenous vein] Napoli, New Print, 1991. Translation and reprint at doi: 10.24019/jtavr.22

70) Passariello F, Carbone R. Chirurgia dell'Arco della Safena Esterna. [Surgery of the arch of the shorter saphenous vein] Min. Angiol. vol. 17, Suppl. 3 al n. 2, pag. 149-156, Ed. Min. Medica, Torino (Aprile-Giugno 1992).

71) Passariello F. The External Saphena Geometry. Surgical choices. VI Réunion de L'Association Européenne de Chiva. Lagos-Agarve, Portugal 2000. Available at the address http://web.tiscali.it/afunc/chivaref/passarie/sext.htm at the date of Feb 28, 2022. Reprint at DOI: 10.24019/jtavr.36

72) Chan CY, Chen TC, Hsieh YK, Huang JH. Retrospective comparison of clinical outcomes between endovenous laser and saphenous vein-sparing surgery for treatment of varicose veins. World J Surg. 2011 Jul;35(7):1679-86 doi: 10.1007/s00268-011-1093-8.

73) Hua Wang, Qianyi Chen, Zhewei Fei, Endong Zheng, Zhanghui Yang, Xiaowang Huang. Hemodynamic classification and CHIVA treatment of varicose veins in lower extremities (VVLE). Int J Clin Exp Med. 2016;9(2):2465-2471

74) Guo L, Huang R, Zhao D, Xu G, Liu H, Yang J, Guo T. Long-term efficacy of different procedures for treatment of varicose veins: A network meta-analysis. Medicine (Baltimore). 2019 Feb;98(7):e14495. doi: 10.1097/MD.0000000000014495.

75) Milone M, Salvatore G, Maietta P, Sosa Fernandez LM. Milone F. Recurrent varicose veins of the lower limbs after surgery. Role of surgical technique (stripping vs. CHIVA) and surgeon's experience. G Chir. 2011 Nov-Dec;32(11-12):460-3