CHIVA: rationale, practice and results

C.Franceschi, M.Cappelli, S.Ermini, S.Gianesini, E.Mendoza, F.Passariello,P.Zamboni

CHIVA is the french acronym of: "**Cure Conservatrice et Hemodynamique de l'Insuffisance Veineuse en Ambulatoire**" (conservative and hemodynamic treatment of the venous insufficiency in outpatients). [1, 2]

CHIVA is a treatment of the venous insufficiency based on a hemodynamic model of the pathophysiology of the venous system proposed in 1988[1, 2, 18]. The conservation, beside the potential graft sparing ,is per se an hemodynamic management aimed to preserve the physiological drainage of the tissues. The Transmural Pressure TMP is regulated by different factors which control the pressure inside and outside the macro and micro venous system. These factors are various and need to be identified in order to correct precisely the ones to treat. That is the reason why the core of the hemodynamic model is the venous Transmural Pressure TMP, which is, when excessive, responsible for veins dilation as varicose veins and drainage impairment as edema, skin disorders and ulcer. CHIVA practice demands diagnosis, strategy and tactics that comply with this hemodynamic model. This is the unavoidable condition for a proper CHIVA achievement. To do that, the CHIVA strategy consists of 4 actions:

1/ Gravitationnal Hydrostatic Pressure (GHP) fractioning.
2/ Closed and open deviated shunts (CS and ODS) disconnection.
3/ Veins and Open Vicarious shunts (OVS) preservation.
4/ In outpatients.

1- TMP is the difference between Lateral Endo-venous Pressure LEP and Extra-venous Pressure EP.

LEP is the sum of 3 distinct pressures: The first one is the **Gravitational Hydrostatic Pressure (GHP)** depending of the body posture. The second one is the **Valvo-Muscular Pressure (VMP)** provided by the action of the muscles of the lower limb, and particularly by the calf. The third one is the **Residual Pressure (RPr)** that is the pressure transmitted by the Arterial Pressure through the micro-circulation. Its value is inversely proportional to the micro-circulation resistance (vasomotion) and proportional to the downstream resistance (venous obstacle or cardiac pump impairment). **The Extra-venous Pressure EP** comprises the **Tissue Pressure + Atmospheric Pressure.** Lowering the tissue or atmospheric pressure increases the TMP without any LEP change. For the same reason, TMP can be reduced by compressive bandaging without LEP modification.

2- Gravitational Hydrostatic Pressure Control: Posture and Dynamic Fractioning of the GHP (DFHP)

RATIONNAL:
***Definition*: Gravitational Hydrostatic Pressure (GHP)** is proportional to the gravitational force g and to the height h of the blood column. GHP= ρgh. Being proportional to the height of the blood column from the foot to the heart, GHP changes at the lower limbs with the **body posture and venous valve closure**.
***Behavior*:** (FIG 3)
Normally, GHP at the ankle is null in recumbent position and ELP is reduced to the RP value around 20mmHg. ELP is negative (i.e lower than the Atmospheric Pressure) when the foot is elevated higher than the heart level. In upright absolutely still position, the venous valves keep open so that GHSP is maximum (around 90mmHg). This posture increases dramatically the TMP and cannot be held for

long period of time without providing venous insufficiency signs and symptoms. The physiological way to reduce GHP in upright position is the alternate closure of the venous valves upstream and downstream the muscular pumps along the lower limbs. Indeed, these alternate closures segment dynamically the blood column, i.e the GHP when walking. So the ELP drops from 90 down to 30 mmHg at the ankle (4, 5). We defined this mechanism as Dynamic Fractioning of the GHP (DFHP) (6) (FIG4).
Pathology: DFPH is impaired by the valve incompetence in proportion to its deep and/or superficial venous network location, level, extension and degree (total, partial, segmental) [8] (FIG 5, 6).

PRACTICE:
Diagnosis: Duplex US scan cannot assess the valve incompetence at rest but only by tests showing a trans-valve reflux (valsalva manoeuver, squeezing, Paranà [8], Wundsdorf, oscillation maneuvers) (FIG 7,8,9). The incompetent paths are reported on the cartography.
CHIVA strategy: Restoring the DHPF can be achieved by two ways. When but rarely feasible, the first one could be the valve repair or prosthetic implant. The second one consists of the superficial incompetent veins division into 50-60 cms segments. Each segment must be correctly drained towards the deep veins by any superficial-deep connection i.e perforator[1,2,18]. Most of the time, these disconnections match with the shunts disconnections (see below).
CHIVA tactics: the divisions are performed according to the strategy, at the US guided skin marks, under local light anesthetics. A segment of1or 2 cms vein is excised and the stumps are ligated with NON absorbable thread. A clip is preferably placed flush the Femoral vein n order to ablate totally the stump A study of the triple ligation TSFL with thick non absorbable thread N°2 versus division has shown equivalent results, allowing a less invasive procedure and probably reducing the risk of neo-angiogenesis [26] Light compression for 2 weeks and preventive anticoagulation for 10 days.

3- Closed and Open Deviated shunts (CS and ODS)

RATIONNAL:
***Venous Networks*:** The understanding of the shunts, needs first of all, an anatomo-functional description of the venous system [1, 18,] ad Teupitz CHIVA Congress Shunts classification FIG 19. It is a classification of the distinct venous networks according to their anatomic compartment and flowing behaviour. Network 3 (N3) is made of the suprafascial triburaries. Network 2 (N2) is made of the intra-fascial saphenous trunks of the Great Saphenous vein GSV, the Anterior Saphenous Vein ASV and Giacomini Vein GV . Network 1 (N1) is made of the deep subfascial veins. Network 4l (N4l) is the suprafascial veins that interconnect longitudinally 2 levels of the same N2 e.g the “accessory GSV”. Network 4t (N4t) is the suprafascial veins that interconnects transversally 2 different N2, e.g “Leonard’s vein connecting the GSV to the Small Saphenous Vein SSV. [34] (FIG 1, 2). This classification previously defined by Duplex ultrasound [1,2] was confirmed by further anatomic studies [3].
Then, in order to achieve a correct drainage of the skin, the flow **obeys a hierarchical direction as follows: N3>N2>N1 or N3>N1**. Changes in this hierarchy represent various pathologic configurations that we classified as different types of shunts.

SHUNTS:
Definition: **According to the fluid dynamics, a shunt is defined as a conduit that diverts a flow of another conduit**. i.e an arterio-venous shunt is a vein that diverts the arterial flow through an abnormal arterio-venous connection. So, we define the **veno-venous shunts as veins that divert the flow of another vein** through an incompetent veno-venous connection i.e Sapheno-femoral junction SFJ (N1>N2), Sapheno-popliteal junction SPJ (N1>N2), perforator (N1>N2 or N1>N3), pelvic leaks (N1>N2 or N1>N3), N2-N3 junction (N2>N3). Practically, the veno-venous shunts reverse the physiological flow hierarchy through a so called **Escape Point EP** that allows the flow diversion.

Then this diverted flow re-enters into N1 through another distant connection so called **Re-entry Point RP** i.e other SFJ, SPJ or Perforator. According to the shunt type, the EP and RP are usually but not always located below or above the knee : Leg perforators, SFJ, SPJ, thigh perforators, pelvic points (Inguinal Point IPoint, Perineal Point PPoint, Clitoridian Point CPoint , Obturator Point OPoint, superior and Inferior Gluteal Points [15,16] (FIG3) . On the other hand, **a shunting vein is always overloaded by the diverted flow and pressure in addition to its draining physiological flow. (FIG 12A ,13A, 13terA). The overloading flow is actioned permanently by the heart responsible for the Residual Pressure that drives the blood drained from the micro-circulation and by the Thoraco-abdominal pump during the respiration. In addition, it is provided occasionally by the action of the Valvo-Muscular Pump (VMP) during the muscular activation i.e when walking. The VMP flow overloads the shunting vein during the muscular contraction (systole) and/or relaxation (diastole) according to the type of shunt. Different types of shunts are anatomically described according to their EP and RP location and their systolic or diastolic activation.**

Closed shunts: (FIG 11, 13)

RATIONNAL:

Definition: CS is a venous pathway, competent or not, that **during the VMP diastole flows in closed circuit (Trendelenburg private circulation)** with the deep shunted veins N1, through its EP and RP.

***Behavior*:** During the VMP diastole, CS is overloaded through an EP by a flow made of N1blood. The resulting excess of pressure and velocity is due to the flow and energy provided by the power of the VMP diastole and to the GHP according to the eight of the incompetent venous pathways below the heart and above the RP (no Dynamic Gravitational Hydrostatic Pressure Fractioned segment).

***Anatomic configurations*:** A superficial CS type is defined by its variable configurations according to its EP, shunting veins and RP. EP are mostly located above the calf and RP at the calf, ankle and foot level. 3 examples: **Shunt 1 pathway is** N1>N2>N1 where N2 is overloaded by N1 and the EP is the SFJ, the SPJ, or a N1>N2 perforator FIG 11. **Shunt 3 pathway is** N1>N2>N3>N1 where the EP are the same as Shunt 1, N2 is also overloaded by N1but N3 is overloaded by by N2+N1. **Shunt 3 pathway is** N1>N3>N1 where N3 is overloaded by N1 through a thigh or leg EP perforator FIG 13. Other configurations are shown in FIG 19.

PRACTICE

***Diagnosis*:** refilling time plethysmography is due to shunts but not specific. **Doppler US is specific of CS EP when the reflux is evoked by the Valsalva maneuver (VM). Indeed, in case of GSV diastolic reflux during the calf compression/release and/or preferably the dynamic maneuvers as Paranà test a competent GSV Terminal Valve can be erroneously confused with a Post Terminal valve and vice versa. Even more specially, the descending tributaries of the GSV arch show a normal descending direction of the flow during these maneuvers, in both absence and presence of a pelvic leak point that overloads it. Conversely, VM shows a descending flow, pathologic despite its normal direction, in case of pelvic leak EP flowing through these tributaries. Blowing into a blocked straw allows an accurate and easy VM FIG 20.** The difference between SHUNT 3 and other CS is assessed by the effect compression of the refluxing tributary N3 on the GSV trunk reflux. In case of SHUNT 3, the ablation of the GSV reflux previously evoked by the Valsalva maneuver attests for the lack of RP N2>N1 along the GSV feeding segment. If the reflux persists ,it is not a SHUNT 3 CS. **The clinical test and at the same time an anticipation of the clinical immediate result can be achieved by tying a tourniquet at the sites where the disconnections are planned and ask the patient to walk a little while. This method, in accordance to the Perthes maneuver, but more accurate, shows the varicose veins collapsing if the strategy/examination is correct. At the same time, the patient have a look to his future condition. (See SHUNT II mapping, Perthes Maneuver, treatment, outcome:** http://www.youtube.com/watch?v=6VHJbeCT4do and CHIVA hypodermitis, varices mapping, pethes, outcome http://www.youtube.com/watch?v=LhVsKs-uo3A

CHIVA strategy:

***SHUNT 1**:* When the EP is the SFJ, CHIVA consists of at the same time disconnecting the CS and fractioning the blood column flush to the Femoral vein and when the reflux extends to the ankle, an additional blood column fragmentation just below the higher perforator of the leg. When the EP is the SPJ, the disconnection is perfomed flush to the Popliteal vein or preferably just below the Giacomini vein junction. When the EP is a thigh , the refluxing perforator (Dodd) is ablated and the GSV trunk is untouched. This SHUNT 1 strategy will result in a still refluxing GSV but no more overloaded, draining its physiological territory according to the physiological hierarchyN2>N1 as attested by the caliber progressive reduction to normal [25] . This residual shunt is called SHUNT0 because no more pathogenic Fig 11B.

***SHUNT 3*:** In the SHUNT 3, N2 doesn't show any perforator. A disconnection at the same time the SFJ and the N2>N3 junction would hamper the GSV drainage, so leading to thrombosis, recurrence by by-passing collaterals (see below OVS) and loss of potential graft. 2 strategies are possible. The first one called CHIVA 2 STEPS (CHIVA 2) consists of disconnecting N3 flush to N2 (STEP 1) , so that N3is though refluxing no more overloaded (SHUNT0). At the same time, the GSV reflux disappears because no more connected to a RP N3>1. Then in most cases, a SFJ reflux occurs after a some months period of time [32,33] due to a GSV trunk Perforator opened by the left behind overloading too high blood column (no fractionation at the SFJ).This perforator plays the role of a RP, resulting in a SHUNT1. The STEP 2 consists of a SHUNT 1 disconnection of the GSV at the SFJ. The second strategy allows a only one step procedure. It consists of the devalvulation of the competent GSV segment below the N2>N3 junction down to a perforator, which results in a SHUNT 1. At the same time double flush disconnection is performed, the GSV at the SFJ and the refluxing tributary at the N2>N3 junction. The hemodynamic result of both SHUNT3 strategies will be two SHUNTS 0 of the GSV and its tributary. Devalvulation may be followed by a transient thrombosis due to the valve wound that is cleared after less than one month.

CHIVA tactics: the divisions or TSL are performed according to the strategy , at the US guided skin marks , under local light anesthetics. A segment of1or 2 cms vein is excised and the stumps are ligated with NON absorbable thread. Devalvulation can be performed by any device.
Light compression for 2 weeks and preventive anticoagulation for 10 days.

Open deviated shunts (ODS).

RATIONNAL

***Definition*:** ODS is a venous pathway N3, that flows in open circuit (no recirculation) through its EP and RP, during the VMP diastole. Flowing N2>N3>N1, it is contrary to the physiological draining hierarchy and consequently pathologic [14]. Fig 14 A

Behavior: ODS differ from CS because their escape points are not connected to N1, but only to the superficial network N2, so **that N2 nor N3 are not overloaded by N1 and doesn't flow in closed circuit but open**. In addition, they are called Open "Deviated "Shunts because, due to the reverse Pressure Gradient VMP, the incompetent tributary N3 aspires and flows down to N1 through its RP at least part of the flow of the N2 where it connects, in addition to its physiologic though refluxing flow. The amount of the N2 refluxing flow into N3 depends on the height of the N2 segment between the N2>N3 junction and the first overlying competent GSV. N3>N2 disconnection leaves behind a N3 SHUNT 0 and a physiological GSV because no more refluxing and protected the GHP by at least the competent Terminal Valve.

Anatomic configuration: **This ODS shunt is called SHUNT 2.** It consists of an incompetent N3 tributary that connects a segmental refluxing saphenous vein (mostly the GSV or rarely the SSV)

Diagnosis: Here also, only Dopper US is capable to diagnoses specifically the ODS. Yet, the ODS is like CS refluxing during the VMP diastole, **BUT contrary to CS, it doesn't show any significant reflux during the VM (Vasalva negative). A short Valslava reflux < 500ms has no noticeable hemodynamic value and represents only the time of the valve closure.**

***CHIVA strategy*:** Disconnection limited to the refluxing N3 at its junction to N1. (Fig 14B). (CHIVA in SHUNT II + Telangectasia:Mapping and aestetic outcomes: http://www.youtube.com/watch?v=JScby8a0zZY)
***CHIVA tactics*:** the divisions are performed according to the strategy [33] , at the US guided skin marks , under local light anesthetics. A segment of1or 2 cms vein is excised and the stumps are ligated at the very N3>N2 junction in order to leave not behind a proximal stump that could be responsible for recurrence. NON absorbable thread. Light compression for 2 weeks and preventive anticoagulation for 10 days.

ODS and CS combination. (Fig 15)

Most of the time, an incompetent tributary is connected to a CS : SHUNT 1 + N3
The only disconnection N2>N3 leaves behind a CS N1>N2>N3 while the only disconnection N1>N2 leaves behind an ODS SHUNT 2. So both disconnections are done at the same time resulting in 2 SHUNTS 0. S (Fig 15) http://www.dailymotion.com/video/x5q55p_chiva-shunt-i-et-ii_tech?search_algo=1

4-Combined deep and superficial venous incompetence: Competitive reflux

This configuration must be depicted. It occurs when a large superficial varicose vein doesn't show any consistent reflux, due to a severe deep reflux that allows no more a diastolic efficient aspiration at the RP, so hampering the CS or ODS re-entry. **It is called "competitive deep reflux" and it is corroborated by the Perthes** maneuver when tourniquet placed at the root of the varice doesn't collapse. Therefore, CS and ODS reflux decreases proportionally to deep reflux severity. So, according to the CHIVA concepts, the shunts disconnections are not indicated if the RP cannot drain into N1.

5-Open Vicarious Shunts. Veins sparing.

RATIONNAL

***Definition*:** Open Vicarious Shunt OVS (Vicarious meaning substitute) is a veno-venous shunt that by-pases a venous obstacle . Usually, it connects to the by-passed vein below the obstacle by an EP , then above the obstacle by a RP.
***Behaviour*: A shunting vein drives its physiological flow that is overloaded in proportion of the amount of the flow upstream and the resistance into the by-passed vein.**
A permanent or dynamic resistant obstacle increases the upstream Residual Pressure in proportion to its resistance to the flow. This excessive residual pressure increases the TMP, so dilating the distal veins and hampering the drainage of the tissues. Progressively, it dilates the collaterals and forces their valves through one or more EP. Contrary to CS and ODS, OVS is NOT activated during the diastole, but only during the VMP systole and sometimes permanently when the by-passed obstacle is more hemodynamically important. As it is a "natural" by-pass, the OVS has to be respected. For that reason OVS have to be respected and not confused with CS and ODS particularly in Mixed Shunts (see below). On the other hand this phenomenon explains part of the varicose recurrence after ablation of superficial veins. Indeed, due to the Residual Pressure, these ablated veins are progressively by-passed by varicose collaterals. This explains that most of varicose recurrence after stripping and other endo-velous procedures are prevented by CHIVA [10].
***Anatomic configurations*:** Contrary to the ODS and CS, the EP of the OVS is most of the time below the RP. For example, in case of femoral vein obstacle (Permanent or dynamic systolic compression) the systolic flow of the calf is too powerful to be totally transmitted without resistance through the femoral vein. Therefore it forces an escape point EP through the incompetent SPJ N1>N2 and flows into the Giacomini vein up to its junction with the GSV, then re-enters into the femoral vein through the competent GSV arch and SFJ (RPa) (FIG 17 A, 17bis A). Thereby, an OVS activated by the calf

systole is formed. (FIG 17 A, 17bis A) . In case of left iliac venous obstacle, the femoral flow (N1) propelled by the ipsilateral limb VMP, can force a reflux through the SFJ (EP) N1>N2 then proceeding through the GSV arch , its upper tributaries (N3) and finally joins the opposite femoral vein (N1) through the opposite GSV arch and its SFJ (RP a) (FIG 17 bis). The OVS is formed.

PRACTICE

Diagnosis: Usually, the flow direction and its activation along the OVS assessed by DUS are not distinct from the normal. Their difference is a systolic reflux N1>N2 or N1>N3 or N2>N3 at the EP. Usually at the below knee perforators overloading the normal antegrade flow of the GSV (OVS of a Popliteal obstacle), at the SPJ overloading the normal antegrade flow of the Giacomini Vein (Femoral obstacle), at the SFJ refluxing into the GSV arch and reversing the flow direction of descending tributaries (Iliac and/or ICV obstacle). In the latter case, the femoral spontaneous flow is no more modulated by the respiration nor the heart rate.
Strategy: CHIVA strategy is preservation of OVS, natural treatment of the venous obstacles.
Tactics: blocked veins liberation when feasible.

6-Mixed Shunts

RATIONNAL

***Definition*:** MS is one or more consecutive veins, competent or not, that plays the role of by-pass (Open Vicarious Shunt OVS) during the VMP systole and the role of CS during the diastole. To do it, the EP and the initial part of the venous path is common to both OVS and CS while the terminal paths and RP are different and divergent.
Behavior: 2 examples:
First example: in case of femoral vein obstacle (obstruction or narrow caliber), the calf VMP systolic flow is too powerful to be transmitted without resistance through the femoral vein. ThereforeN1 forces the SPJ valve (EP) and refluxes into the Giacomini vein up to its junction with the GSV then re-enters into the common femoral vein through the competent GSV arch and SFJ (RPa). Thereby, an OVS activated by the VMP systole is formed. If the GSV below its junction with the Giacomini V is incompetent and refluxes down to N1 through a below knee perforator (RPb), a CS is formed. The latter shares the same SPJ EP and Giacomini pathway with the OVS, while their terminal pathways and rentries RPa and RP b diverge distally for the first one and proximally for other one. (FIG 16A, 16 bisA). Systo-diastolic reflux in Giacomini vein and varices of LSV. https://www.youtube.com/watch?v=iDmuhO8fuuk&feature=youtu.be
Second example : In case of left iliac venous obstacle, the femoral flow (N1) propelled by the VMP, can force and reflux through the SFJ valve (EP) then through the GSV arch and its upper tributaries (N3) and finally join the right femoral vein (N1) through the right GSV arch and its SFJ (RP a) . The OVS is formed. If the left GSV is incompetent and refluxing during the VMP diastole distally down to N1 through a perforator (RP b), a CS is formed. This CS shares with OVS the SFJ RP and the GSV arch while their successive pathways diverge and their re-entries are distinct**. (**FIG 17 A, 17bis A)
Anatomic configurations: MS are possible anywhere on condition that OVS and CS share their EP while their RP are distinct.

PRACTICE

Diagnosis: The diagnosis is feasible only with Duplex US and relies on the assessment of successive diastolic and diastolic reflux in the same EP and initial pathway, that changes in unique diastolic flow in the RP and final pathway of the CS and unique systolic flow in the terminal OVS. A Doppler pressure measurement at the ankle, in supine position, can be performed when the part of TMP excess due to the obstacle (residual pressure excess) has to be assessed.

CHIVA strategy

It consists in disconnection of the terminal branch of CS at it separation from the distal OVS branch, in order to treat the first one and preserve the other**. (FIG 16B, 16 bisB ,17B, 17bisB)**

CHIVA tactics

The divisions are performed according to the strategy, at the US guided skin marks, under local light anesthetics. A segment of1or 2 cms vein is excised and the stumps are ligated at the very N3>N2 junction in order to leave not behind a proximal stump that could be responsible for recurrence. NON absorbable thread. Light compression for 2 weeks and preventive anticoagulation for 10 days.

7-Combined deep obstruction and superficial venous incompetence

The deep venous network incompetent can include CS detectable according to the superficial CS concept, and OVS due to obstructions when by-passed by superficial veins (see above: MS).

8-GSV preservation

The reason for the GSV preservation is double: preserving the potential material for future need of arterial by-pass and reducing the varicose recurrence rate. " Autogenous vein is superior to synthetic graft as conduit for LEB and the great saphenous vein (GSV) is superior to other autologous alternatives… Open infrainguinal bypass remains the gold standard for revascularization in CLI, especially for patients at appropriate surgical risk and with suitable bypass conduit" [20] .

9- Venous Malformation

The basic hemodynamics of Venous malformations , despite made of truncular and/or extra-truncular veins doesn't differ from the others. Indeed, they obey the hemodynamics laws and are made of any type of shunt. OVS when compensating veins thrombosis, absence or hypoplasia, CS when part of overloading reflux in an incompetent vein is fed by a competent collateral with witch it is connected by an escape point and a re-entry point. The extra-truncal malformations that doesn't play any consistent draining role and appear as very low /static flow in the muscles, the articulation, around the neuro-vascular bundles , under and intra cutaneous. So CHIVA strategy for truncal malformations doesn't differ from non malformative veins, in terms of shunts treatment (see above). The extra-truncal malformations with poor tissue draining function are ablated when symptomatic and/or responsible for PE and preferably surgically. The peculiar case of marginal vein strategy relies on the necessity to preserve this vein when compensatory of femoro-popliteal hypoplasia (OVS) and/or draining a superficial capillary angioma (increased residual pressure) [19]

Results

Clinical and instrumental assessment of the resultsts [10,11,12,13,17]

Clinical and instrumental checking is performed 1 month later and further in case of clinical new event (varicose and/or trophic disorders reccurence).

Success: Hemodynamically: not by-passed nor recanalized disconnections. Varicose veins caliber reduction. No reflux at Valsalva maneuver in treated N1>N2 or N3>N1 nor in the underlying veins. No diastolic reflux through the treated N1>N2 or N3>**N1 WHILE reflux remains in the treated veins BUT no more overloaded**. Clinically: Immediate varices collapse when walking and progressive caliber reduction with time (weeks) of the veins caliber in standing still position. Progressive GSV caliber reduction **[**25 **]** but quick healing of signs and symptoms aimed by the treatment. See : Shunt I + II strategy + Treatment http://www.dailymotion.com/video/x5q55p_chiva-shunt-i-et-ii_tech?search_algo=1 and Perineal escape point: mapping, Perthes maneuver, treatment and outcome: http://www.youtube.com/watch?v=UHDEMwXPbhw

FAILURE:

Real failure:

Hemodynamically missed or by passed disconnections (short, mid and long term follow up) assessed by Doppler reflux triggered by the dynamic tests (see 31 above). Stasis/thrombosis due to lack of proper drainage (too small or absent re-entry). Clinically: lasting veins dilation in standing still position or varicose recurrence of the previously treated and skin disorders recurrence. The recurrence can be caused by by-passed or recanalized disconnections. They can be due to excessive disconnection when hampering the physiological drainage just like the recurrences secondary to extensive endo/extra ablative methods.

Success/failure confusion:

Venous reflux induced by squeezing/Paranà/Wundsdorf/Oscillation maneuvers while disconnections are not recanalized nor by-passed and valsalva maneuver negative, is NOT pathological but physiological (draining the corresponding territory towards N1).

Transitory/pseudo failure:

Delayed constant collapse of varices while the hemodynamic condition are correct: can be achieved within 3 months (delayed remodeling).

Short thrombosis

Extended GSVthrombosis after Shunt 3 valve destruction is frequent but spontaneously cleared within 1 month.

Trials

Beside several studies [27,28,29,30,31] demonstrated the better results of CHIVA vs the ablative methods represented by Stripping considered as the classical gold standard. Among them, four RCTs reviewed by the Cochrane library [24]: Main results: Four clinical trials from among 434 publications were included with a total of 796 patients (70.5% women). Three RCTs compared the CHIVA method with vein stripping, and one RCT compared the CHIVA method with compression dressings in patients with venous ulcers. Methodological quality of the studies included in this review was low to moderate. The risk of overall bias of the studies was high because the participants and the outcome assessors were not blinded to the interventions. The primary endpoint, clinical recurrences, showed favourable results for the CHIVA method group compared to stripping (n = 721; RR 0.63; 95% CI 0.51 to 0.78; I2 = 0%, NNTB 6; 95% CI 4 to 11) and compression dressings (n = 47;RR 0.23; 95% CI 0.06 to 0.96; NNTB 3; 95%CI 2 to 17). Only one study reported quality of life and results significantly favoured the CHIVA method.
The vein stripping group had a higher risk of side effects than the CHIVA group; specifically, the RR for bruising was 0.63 (95% CI 0.53 to 0.76; NNTH 4; 95% CI 3 to 6) and the RR for nerve damage was 0.05 (95%CI 0.01 to 0.38; I2 = 0%; NNTH 12; 95% CI 9 to 20). There were no differences between groups regarding the incidence of limb infection or superficial vein thrombosis.Authors' conclusions:The CHIVA method reduces recurrences of varicose veins and produces fewer side effects than vein stripping. However,studies are needed to confirm these conclusions since they are based on clinical trials with a high risk of bias.
A retrospective study CHIVA vs EVL concludes "The CHIVA patients had less pain postoperatively and a significantly higher sclerotherapy-free period compared to patients in the EVL group" **[23]**.

CHIVA vs Compression

A RCT CHIVA vs Compression shows the CHIVA prevalence in terms of healing and long term recurrence [35

A peculiar consideration regards the necessity of a proper knowledge of the hemodynamic concepts, the diagnosis assessment and the strategy and tactics demanded by CHIVA, in order to achieve these results. "less recurrence CHIVA vs Stripping when performed by "experts but more recurrences when performed by not experts"(21). "Results with preservation of the saphenous vein. Results with CHIVA. Two RCTscompared standard treatment (compression or high ligation, stripping, and phlebectomy) with CHIVA approaches with specific anatomic patterns of reflux (types I and III shunts). For the specific venous anatomy evaluated in these trials, **such techniques were better than compression in preventing ulcer recurrence and were at least equivalent to stripping of varicose veins.** Although the first two RCTs focused on a small group of patients with varicose veins, the trial of Pares et al192 deserves credit for including the full spectrum of patients with primary varicose veins. CHIVA is a complex approach, and **a high level of training and experience is needed to attain the results presented in this RCT**. However, the results achieved by a few outstanding interventionists does not support offering this procedure to all practitioners. Although CHIVA has called attention to the importance of directing surgical procedures toward the patient's venous anatomy and function**, it still requires considerable education of venous interventionists willing to learn this approach"**. [22].

CONLUSION

CHIVA is a performant alternative to the other treatment of the chronic venous insufficiency. Beside its good results and less recurrences, it preserves the GSV as a possible future arterial by-pass more that increase with the aging population. Its hemodynamics basis rely on renewed concepts and paradigms that would improve the knowledge, diagnosis ant treatments of the venous insufficiency, regarding not only superficial but also the deep veins and the venous malformations. ". Although CHIVA has called attention to the importance of directing surgical procedures toward the patient's venous anatomy and function**, it still requires considerable education of venous interventionists willing to learn this approach" P.Glovczki.**

To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science
Albert Einstein
"Make things as ***simple*** as possible, but not ***simpler***".

References

1) *Franceschi C. La Cure Hemodynamique de l'Insuffisance Veineuse en Ambulatoire.Journal des Maladies Vasculaires. 1997 ; 22 (2) :91-95*
2) *Franceschi C. Théorie et pratique de la cure Conservatrice et hémodynamique de l'insuffisance veineuse en ambulatoire. Precy-sous-Thil France Editions de l'Armançon;1988ref)*
3) *Caggiati A. The saphenous venous compartments. Surg Radiol Anat 1999; 21(1):29-34*
4) *Bjordal R. "Simultaneous pressure and flow recordings in varicose veins of the lower extremity" Acta Chir Scand 1970; 136:309-317*
5) *Recek C, Pojer H. Ambulatory pressure gradient in the veins of the lower extremity. VASA 2000; 29:187-90*
6) *Franceschi C. Dynamic fractionizing of hydrostatic pressure, closed and open shunts , vicarious varicose evolution: how these concepts made the treatment of varices evolve? Phlebologie 2003; 56, (1): 61-66*
7) *Labropoulos N, Tiongson J, Pryor L, Tassiopoulos AK, Kang SS, AshrafMansour M, Baker WH. Definition of venous reflux in lower-extremity veins. J Vasc Surg. 2003 Oct;38(4):793-8]).*
8) *Franceschi C. Measures and interpretation of venous flow in stress tests. Manual compression and Parana manoeuver.Dynamic reflux index and Psatakis index. Journal des Maladies Vasculaires 1997;22(2):91–5*
9) *P.Zamboni and all: Minimally Invasive Surgical management of primary venous Ulcer vs. Compression Eur J vasc Endovasc Surg 00,1 6 (2003)*
10) *Carandina S, Mari C, De Palma M, Marcellino MG,Cisno C, Legnaro A, et al.Varicose Vein Stripping vsHaemodynamic Correction (CHIVA): a long term randomised trial. European Journal of Vascular and Endovascular Surgery 2008;35(2):230–7*
11) *Parés JO, Juan J, Tellez R, Mata A, Moreno C, Quer FX,et l.Varicose vein surgery: stripping versus the CHIVA Method: a randomized controlled trial. Annals of Surgery 2010;251(4):624–31*
12) *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.*
13) *P.Zamboni and all: Minimally Invasive Surgical management of primary venous Ulcer vs. Compression Eur J vasc Endovasc Surg 00,1 6 (2003)*
14) *P. Zamboni*, S. Gianesini, E. Menegatti, G. Tacconi, A. Palazzo, A. Liboni "Great saphenous varicose vein surgery without saphenofemoral junction disconnection" British Journal of Surgery Volume 97, Issue 6, pages 820–825, June 2010*
15) *Franceschi. C, Bahnini A. Treatment of lower extremity venous insufficiency due to pelvic leak points in women Ann Vasc Surg 2005; 19:284-8*
16) *Franceschi C Anatomie fonctionnelle et diagnostic des points de fuites bulbo-clitoridiens chez la femme (Point C) Journal des Maladies Vasculaires Volume 33, numéro S1page 42 (mars 2008)*
17) *Mendoza E, Berger V, Zollmann C, Bomhoff M, Amsler F. Diameter-reduction of the great saphenous vein and common femoral vein after CHIVA. Phlebologie*
18) *Franceschi C, Zamboni P. Principles of venous haemodynamics. Novapublishers. New York. 2010*
19) *Laurian, C.;Franceschi, C. Herbreteau, D.;Enjolras, O Traitement chirurgical des malformations vasculaires des membres. . EMC - Chirurgie vol. 1 issue 2 April, 2004. p. 100-124*
20) *Pennywell DJ, Tan TW, Zhang WW . OPTIMAL management of infrainguinal arterial occlusive disease. http://www.dovepress.com/article_18926.t34346121*

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

22) *The care of patients with varicose veins and associated chronic venous diseases: Clinical practice guidelines of the Society for Vascular Surgery and the American Venous Forum. Peter Gloviczki, MD, and al. JVS 2011*

23) *Chan, C.-Y.a , Chen, T.-C.b , Hsieh, Y.-K.a , Huang, J.-H.c .Retrospective comparison of clinical outcomes between endovenous laser and saphenous vein-sparing surgery for treatment of varicose veins (2011) World Journal of Surgery, 35 (7), pp. 1679-1686.*

24) *Bellmunt-Montoya S, Escribano JM, Dilme J, Martinez-Zapata MJ. CHIVA method for the treatment of chronic venous insufficiency. Cochrane Database of Systematic Reviews 2012, Issue 2. Art. No.: CD009648. DOI:10.1002/14651858.CD009648.*

25) *S.De Francisis, V.Gasbarro, B.Amato, G.Buffone, R.Grande, R.Serra. Hemodynamic surgery versus conventional surgery in chronic venous disease: a multicenterretrospective study. Acta Phlebologica. 2013;14:109-14*

25) *Mendoza, E.[a], Berger, V.[b] , Zollmann, C.[c] , Bomhoff, M.[d] , Amsler, F.[e] Diameter-reduction of the great saphenous vein and common femoral vein after CHIVA [Kaliberreduktion der V. saphena magna und der V. femoralis communis nach CHIVA] (2011) Phlebologie, 40 (2), pp. 73-78.*

26) *Roberto Delfrate, Massimo Bricchi, - Claude Franceschi, Matteo Goldon .Multiple ligation of the proximal greater saphenous vein in the CHIVA treatment of primary varicose veins. Veins and lymphatics. Vol 3, No 1 (2014)*

27) *Fichelle, J.M., Carbone, P., Franceschi, C. Results of ambulatory and hemodynamic treatment of venous insufficiency (CHIVA cure) (1992) J Mal Vasc, 17, pp. 224-228. 1431610 1:STN:280:DyaK3s%2FlslWgsA%3D%3D (French)*

28) *Cappelli, M., Lova, R.M., Ermini, S., Turchi, A., Bono, G., Bahnini, A., Franceschi, C. Ambulatory conservative hemodynamic management of varicose veins: Critical analysis of results at 3 years (2000) Annals of Vascular Surgery, 14 (4), pp. 376-384. DOI 10.1007/s100169910064*

29) *Zamboni, P., Marcellino, M.G., Cappelli, M., Feo, C.V., Bresadola, V., Vasquez, G., Liboni, A Saphenous vein sparing surgery: Principles, techniques and results (1998) Journal of Cardiovascular Surgery, 39 (2), pp. 151-162*

30) *Mendoza, E.Therapy options in refluxive great saphenous vein. Consensus between stripping, sonoguided foam sclerotherapy, endoluminal procedures and CHIVA as therapeutic options [Therapie der stammvarikose der V. saphena magna. Konsens unter einbeziehung von stripping, verödung, endoluminalen verfahren und CHIVA als therapie optionen] (2011) Phlebologie, 40 (3), pp. 159-164.*

31) *Maeso, J.Comparison of clinical outcome of Stripping and CHIVA for tratment of varicose veins in the lower extremities (2001) Annals of Vascular Surgery, 15 (6), pp. 601-605.*

32) *Zamboni P et al. Reflux Elimination Without any Ablation or Disconnection of the Saphenous Vein. A Haemodynamic Model for Venous Surgery .Eur J Vasc Endovasc Surg 2001;21:361-369*

33) *P. Zamboni M.D, S. Gianesini M.D., E. Menegatti R.V.T., G. Tacconi M.D., A. Palazzo M.D., A. Liboni M.D. Avoiding saphenofemoral junction disconnection in varicose vein surgery Britsh Journal of Surgery*

34) *Cappelli M., S. Ermini, A. Turchi, G. Bono, R. Molino Lova Considérations hémodynamiques sur la vidange saphénienne" Phlébologie 1995, 48, 4: 491-498.)*

35) *P.Zamboni and all. Minimally Invasive Surgical management of primary venous Ulcer vs. Compression Treatment: a randomized Clinical Trial.Eur J vasc Endovasc Surg 00,1 6 (2003)*

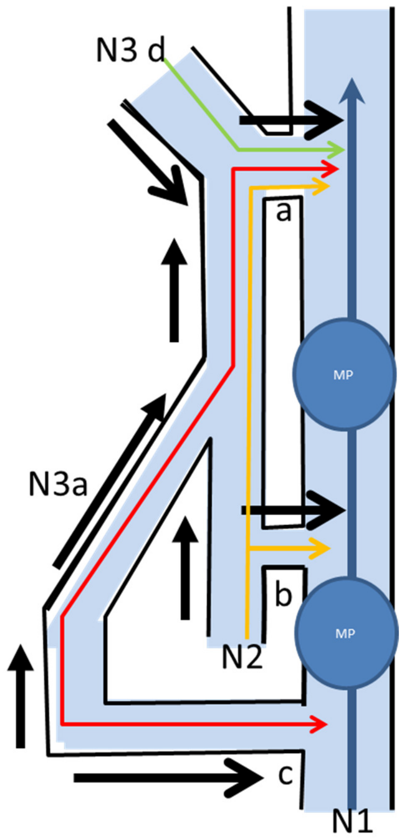

Figure 1. Venous networks hierarchy

N1: deep veins, N2: Saphenous trunks and arches, N3a: ascending GSV tributaries, N3d: descending arches tributaries, a: N2-N1 junction (here SFJ) , b: N2-N1 perforator, c: N3-N1 perforator, MP: muscular pump

Black arrow: Normal content outflow whatever the direction

Red line: normal N3a content outflow and direction, Green line: Normal N3d content and direction, Yellow line: GSV Normal content outflow and direction,Blue line: Deep venous outflow

Normal hierarchal drainage: N3>N2>N1, N3>N1, N3>N2>N1. Here N3a>N2>N1, N3a>N1, N3d>N2>N1. This is a GSV example but can be made of SSV and any N2-N1 or N3-N1 connections.

FIG: 2 : Hierarchical venous drainage, network classification and superficial >deep veins connection.

N1: Deep veins, N2: Sub Fascial supericical veins (GSV, SSV, Giacomini) , N3: Suprafascial superficial veins (GSV and SSV tributaries and extrasaphenous),

N4L: N3 longitudinal inter-N2 connecting , N4T: N3 transversal inter-N2 connecting

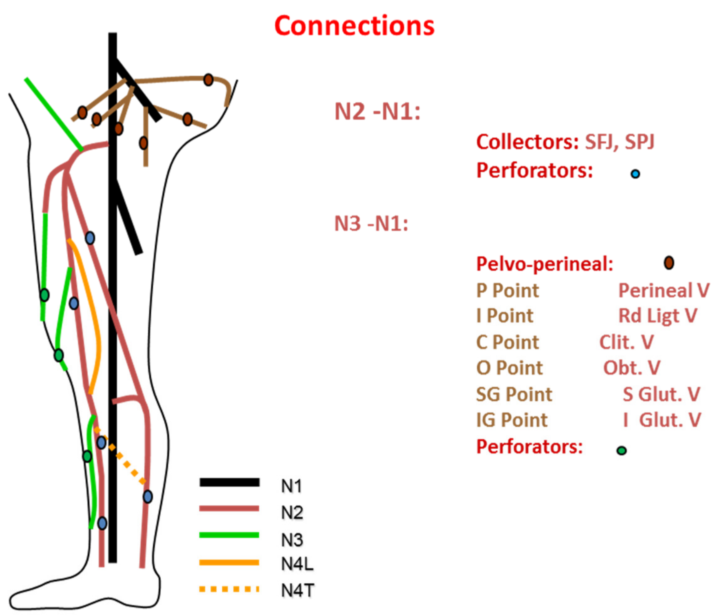

Figure 3: Venous incompetence and gravitational Hydrostatic Pressure

The invasive pressure measurement at the ankle shows no difference between normal and incompetent patients in various positions (standing still, lying down and elevated extremities) while the difference is dramatic during walking-like manoeuvers which make it decrease down to 30 mmHg in normal while it remains high proportionally to the degree of valve incompetence .

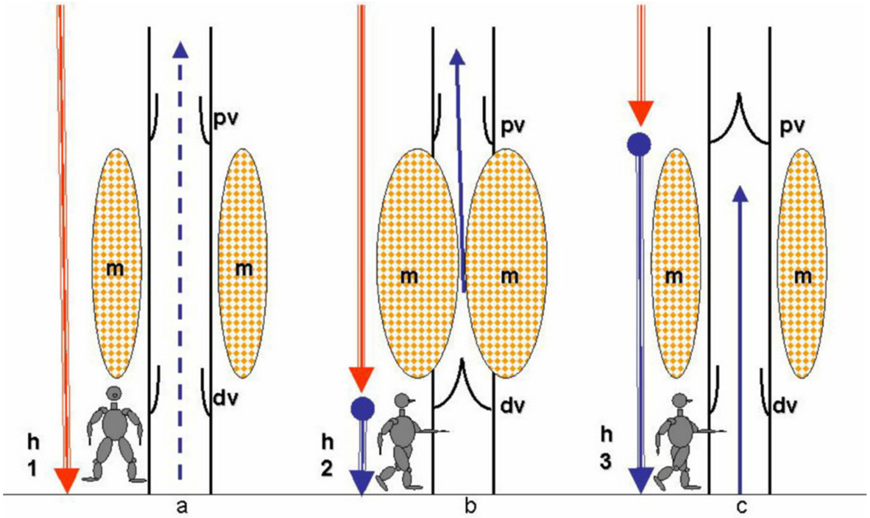

Figure 4. Physiological Dynamic Fractionation of Hydrostatic Pressure DFHP: alternate valve closure reduces hydrostatic pressure HSP by segmenting the height of the venous blood column. Effect of the valvulo-muscular pump VMP of the calf when walking GHSP: Gravitational Hydrostatic pressure. h: Height of venous blood column m: calf VMP muscles. Dv : distal calf VMP valve pv: proximal calf VMP valve. a: Standing strictly immobile. No DFPH :VMP at rest. Open VMP valves. h1: maximum height. b :Walking. DFHP: distal VMP valve closed by VMP systole. h2 : reduced eight at the dv level c: :Walking. DFHP: proximal VMP valve closed by VMP diastole. h3 : reduced eight at the pv level.

From “ Principles of l Venous Hemodynamics. C.Franceschi, P.Zamboni Nova Science Publishers 2009 “

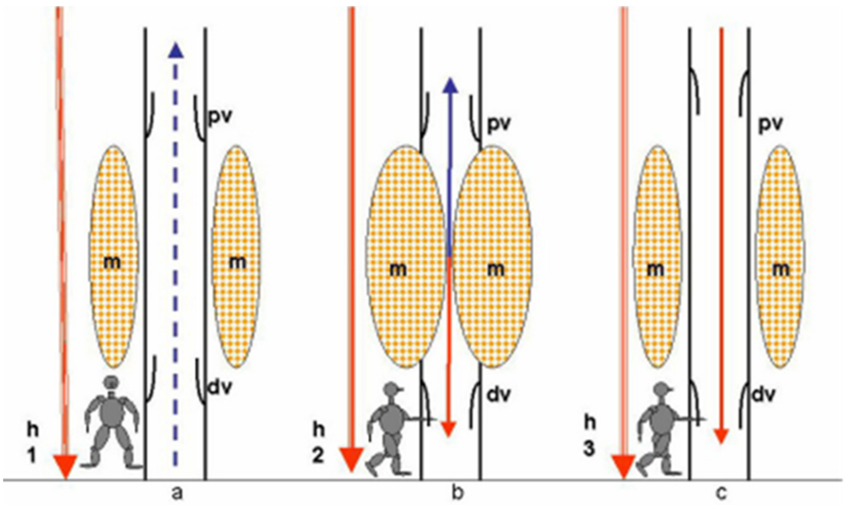

Figure 5. Impaired Dynamic Fractionation of Hydrostatic Pressure DFHP in case of deep venous incompetence DVI. Due to deep valves incompetence, valvulo-muscular pump VMP valve alternate closure is no more waterproof and does not achieve a complete segmentation of the venous blood column. h: Height of venous blood column m: calf VMP muscles. Dv : incompetent distal calf VMP valve pv: incompetent proximal calf VMP valve. a: Standing immobile. No DFPH :VMP at rest. Open VMP valves. h1: maximum height. b :Walking. DFHP: distal VMP valve remains open despite the VMP systole. h2 : no HSP reduction at the dv level c: :Walking. DFHP: proximal VMP valve remains open despite the VMP diastole. h3 : no HSP reduction at the pv level.

From “ Principles of l Venous Hemodynamics. C.Franceschi, P.Zamboni Nova Science Publishers 2009 “

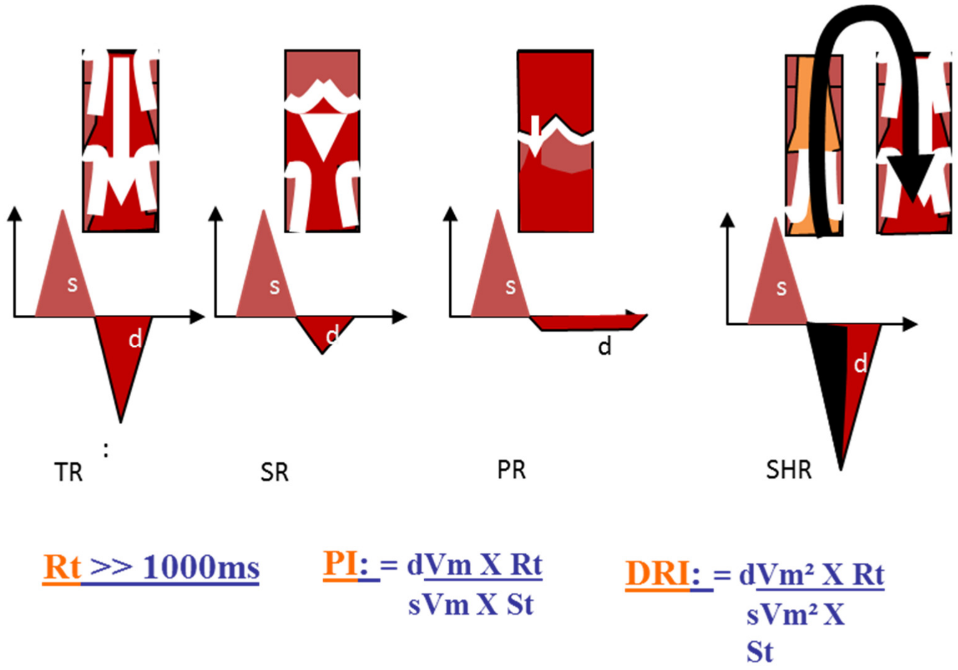

Figure 6: Diastolic Reflux grades in deep and superficiel veins except the perofartors.
Diastolic refluxes: s: MP systole, d: MP diastole
TR: Total reflux when all the overlying valves are totally incompetent
SR: Segmental reflux when at least one or more overlying valves are competent
PR: Partial reflux when the overlying valves are not totally incompetent.
SHR: Shunt reflux when the incompetent vein is fed and overloaded by the blood flowing from other veins.
Rt : diastolic reflux time , s: systolic flow velocty, d: diastolic reflux velocity, flux , dVm: Diastolic reflux mean velocity, sVm: Systolic flow mean velocity.
PI: Psatakis Index, DRI: dynamic reflux index

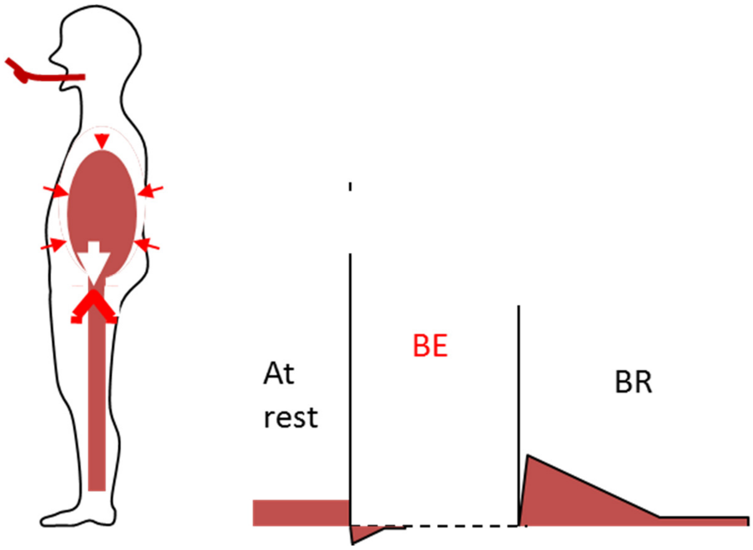

Figure7. Valsalva maneuver (here performed by blowing in a blocked straw) . When normal (valsalva negative) the valves are competent : The blocked expiration (BE) reverses strongly the pressure gradient that induces only a negligible short and small reflux thanks to the correct competence of the underlying valves. At the blockage release (BR) , the pressure gradient turns cardiopetal and induces an ascending flow.

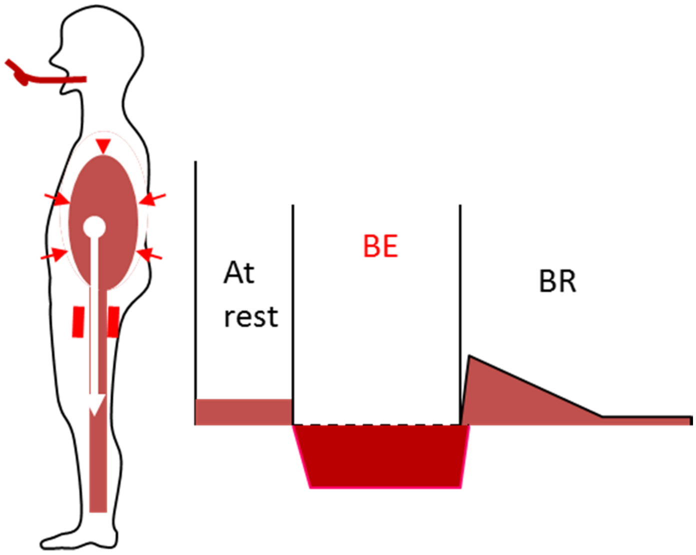

Figure 8. Valsalva maneuver :pathological reflux(valsalva positive)

Valsalva is Positive when valves are Incompetent . Reverse Flow appears when blowing (Blocked expiration BE) and turns back cardiopetal at release (BR)

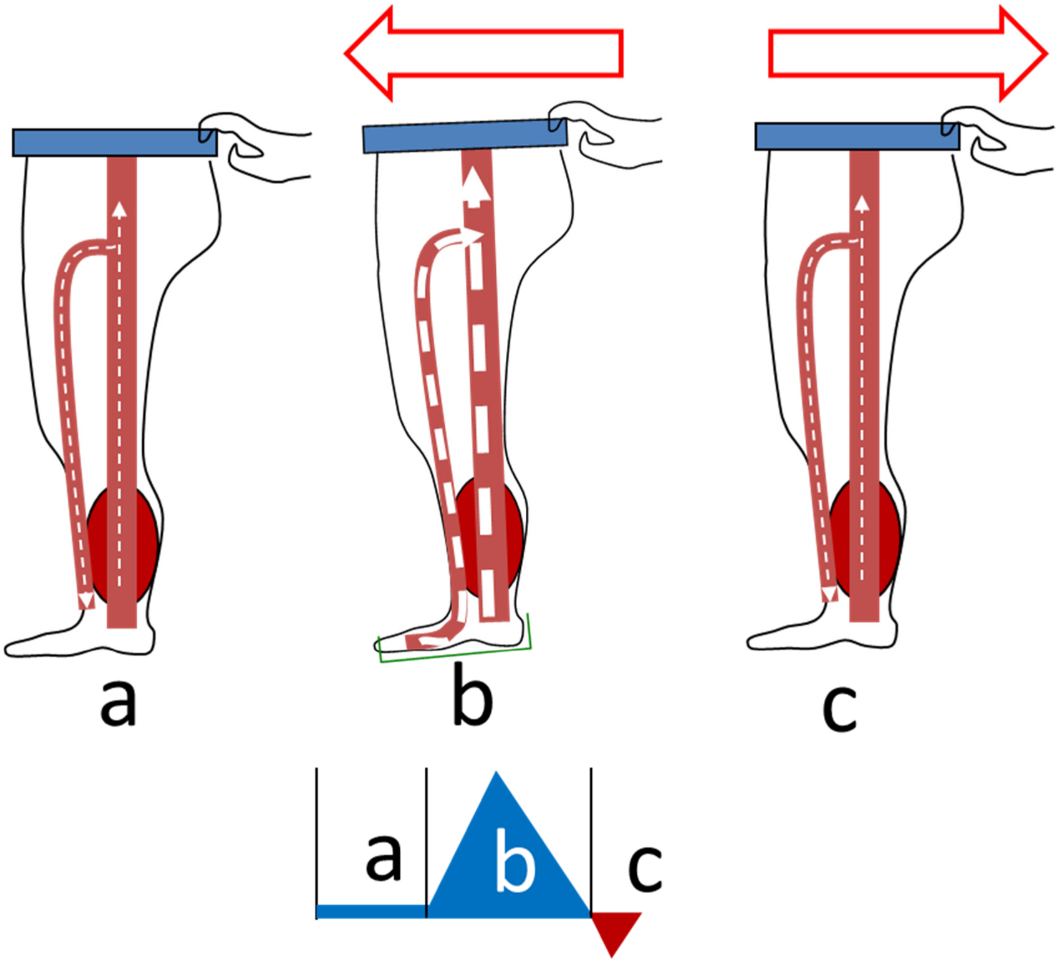

Figure 9 : Paranà maneuver
a: at rest, b: slight push at the waist triggers a proprioceptive reflex calf and sole pumps activation (systole) followed by a very short reflux c < 1000ms (diastole).

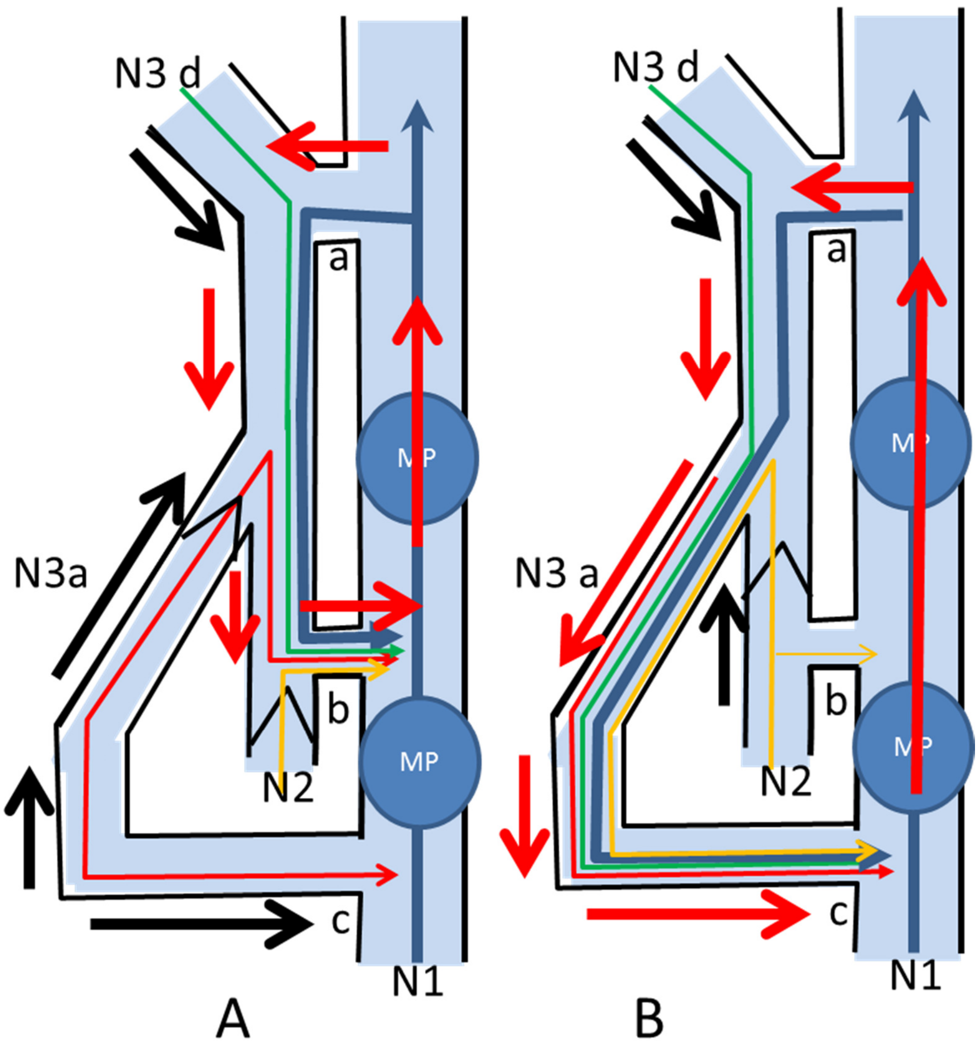

Figure 11: Closed shunt 1 disconnection and shunt 0

N1: deep veins , N2: Saphenous trunks and arches, N3a: ascending tributaries, N3d: arches descending tributaries, a: N2-N1 junction (here SFJ) , b: N2-N1 perforator.Black arrow: Normal outflow whatever the direction, Red arrow: Overloaded flow whatever the direction. Red line: normal N3a outflow whatever the direction, Green line: Normal N3d outflow the direction, Yellow line: Normal GSV outflow whatever the direction , Blue line: Deep venous outflowA: Closed shunt N1>N2>N1: Reflux VALSALVA POSITIVEEscape point (here SFJ a) . Shunt 1 : N2 overloaded by N1 and re-entry N2-N1 b.
B: N1>N2 disconnection D. GHP column fractioned + N1>N2 overloading suppressed = Shunt0, physiological drainage despite reflux (VALSALVA NEGATIVE)

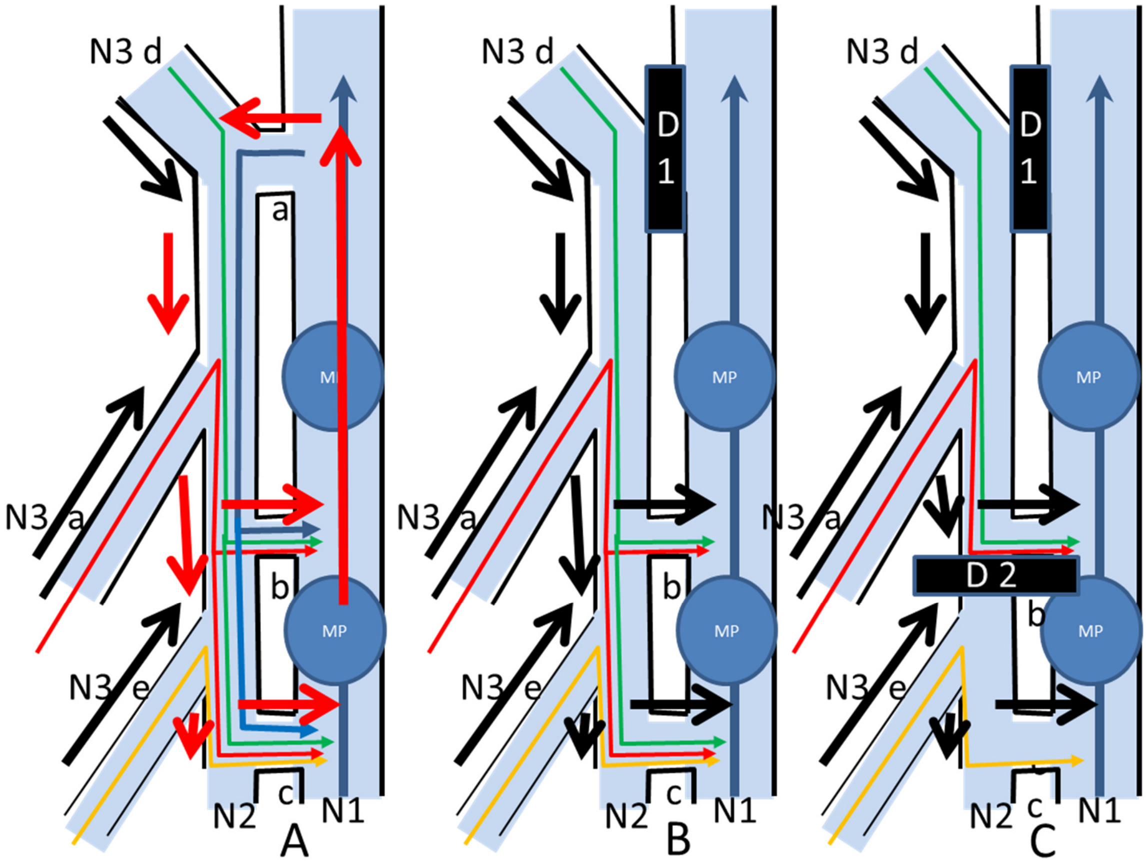

Figure12: Hemodynamic and conservative strategy : an example of 2 staged re-entries Shunt 1.

GHP fractionation(D1) restores the DHPF at the groin level and disconnections suppress the CS N1>N2>N1 no more VALSALVA POSITIVE and drain through 2 staged re-entries b and c. If the is extended all along the trunk, the GHP can be not sufficiently fractioned by D1. In that case, an additional GHP fractioning is implemented just below re-entry b.

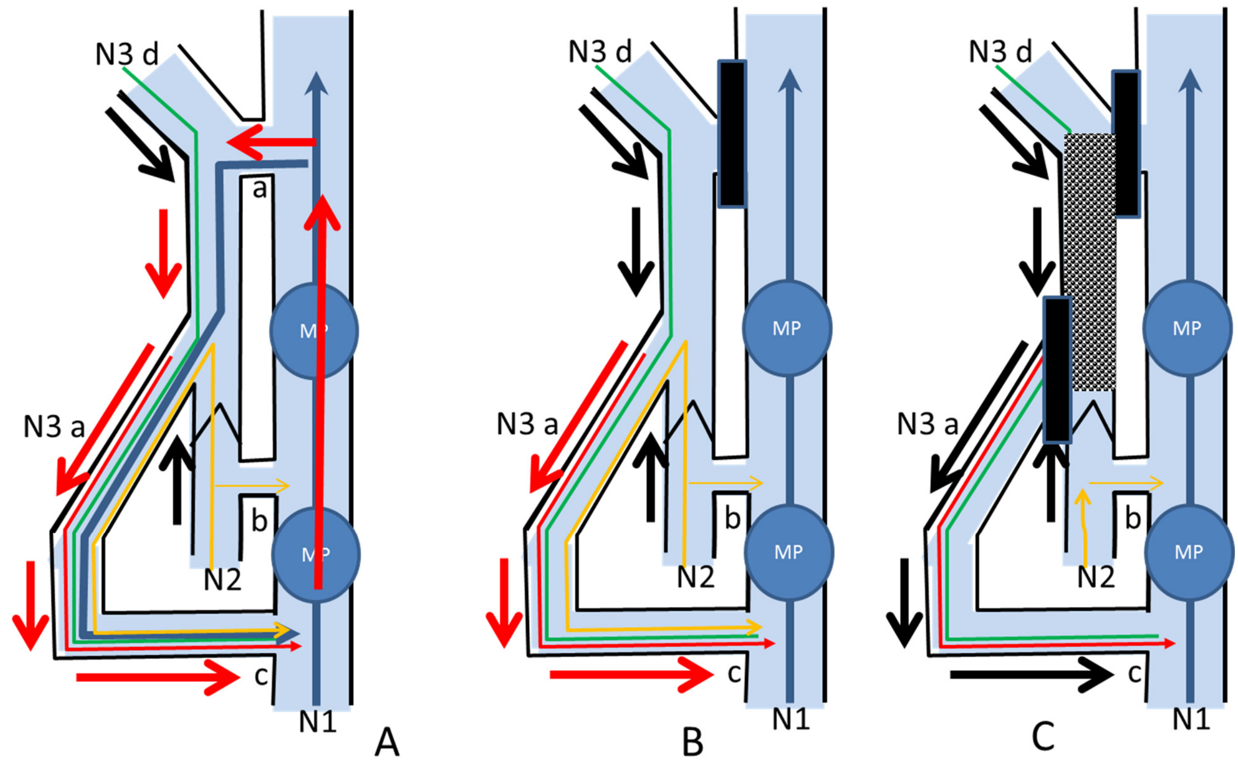

Figure 13. Closed shunt 3 management

N1: deep veins , N2: Saphenous trunks and arches, N3a: ascending tributaries, N3d: arches descending tributaries, a: N2-N1 junction (here SFJ) , b: N2-N1 perforator, c: N3-N1 perforator, MP: muscular pump, o:obstacle.Black arrow: Normal outflow whatever the direction, Red arrow: Overloaded flow whatever the direction. Red line: normal N3a outflow whatever the direction, Green line: Normal N3d outflow the direction, Yellow line: Normal GSV outflow whatever the direction , Blue line: Deep venous outflow

A: CS type shunt 3: VMP Diastolic phase: N1>N2>N3>N1. . Here N1 overloading SFJ a (escape point) and GSV refluxing down into a refluxing tributary N3 then to antegrade re-entry perforator c then into N1 (VALSALVA POSITIVE).

B: The EP disconnection relieves properly the N1>N2 overload but leaves behind the N2>N3 reflux VALSALVA NEGATIVE.

C: The additional EP N2>N3 disconnection can treat properly N3 but hampers the overlying N2 drainage because of the absence of intermediate re-entry and leads to N2 stasis/thrombosis and by-pass/recanalization N2>N3, because hemodynamically incorrect.

N2>N3 disconnection alone treats N3 and provides the N2 reflux ablation and caliber reduction (suppresses the overload from N1), but leaves behind a too high column that secondarily can leads to a recurrent reflux through a forced N2 intermediate valve or perforator or through a N2>N3 recanalization/by-pass. This procedure is called CHIVA 2 steps where the first step consists in N2>N3 disconnection and the second step in proximal N1>N2 disconnection when the reflux occurs along the follow up. Therefore, a destruction of the competent underlying valves down to a RP perforator is combined at the same time with N1>N2 and N2/N3 disconnection.

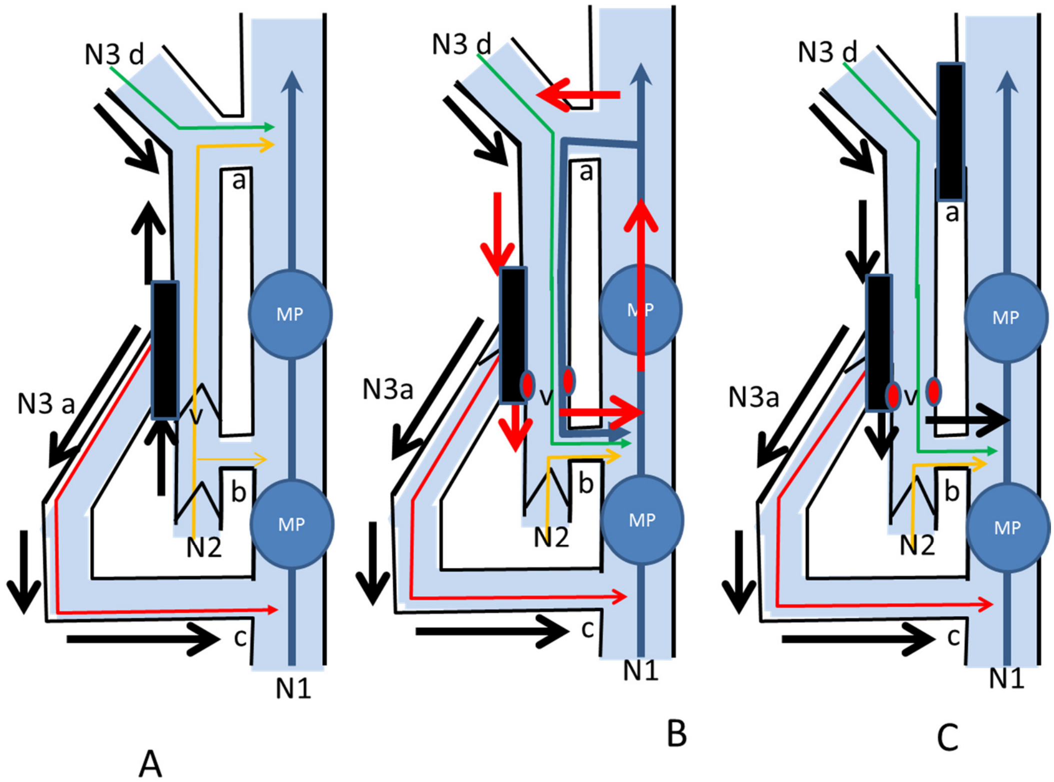

Figure 13bis. Closed shunt 3 management

N1: deep veins , N2: Saphenous trunks and arches, N3a: ascending tributaries, N3d: arches descending tributaries, a: N2-N1 junction (here SFJ) , b: N2-N1 perforator, c: N3-N1 perforator, MP: muscular pump, o:obstacle.Black arrow: Normal outflow whatever the direction, Red arrow: Overloaded flow whatever the direction. Red line: normal N3a outflow whatever the direction, Green line: Normal N3d outflow the direction, Yellow line: Normal GSV outflow whatever the direction , Blue line: Deep venous outflow

A: 1rst Step of the shunt 3 2steps strategy (CHIVA 2): N2>N3 disconnection

N2>N3 disconnection alone treats N3 and provides the N2 reflux ablation and caliber reduction (suppresses the overload from N1), but leaves behind a too high column that secondarily can lead to a recurrent reflux

B: Recurrent reflux through a forced N2 intermediate valve v down to an underlying perforator b = shunt1 .

C: 2nd Step of the shunt 3 2steps strategy: proximal shunt 1 N1>N2 disconnection = shunt0 when the reflux occurs Therefore, a destruction of the competent underlying valves down to a RP perforator is combined at the same time with N1>N2 and N2/N3 disconnection

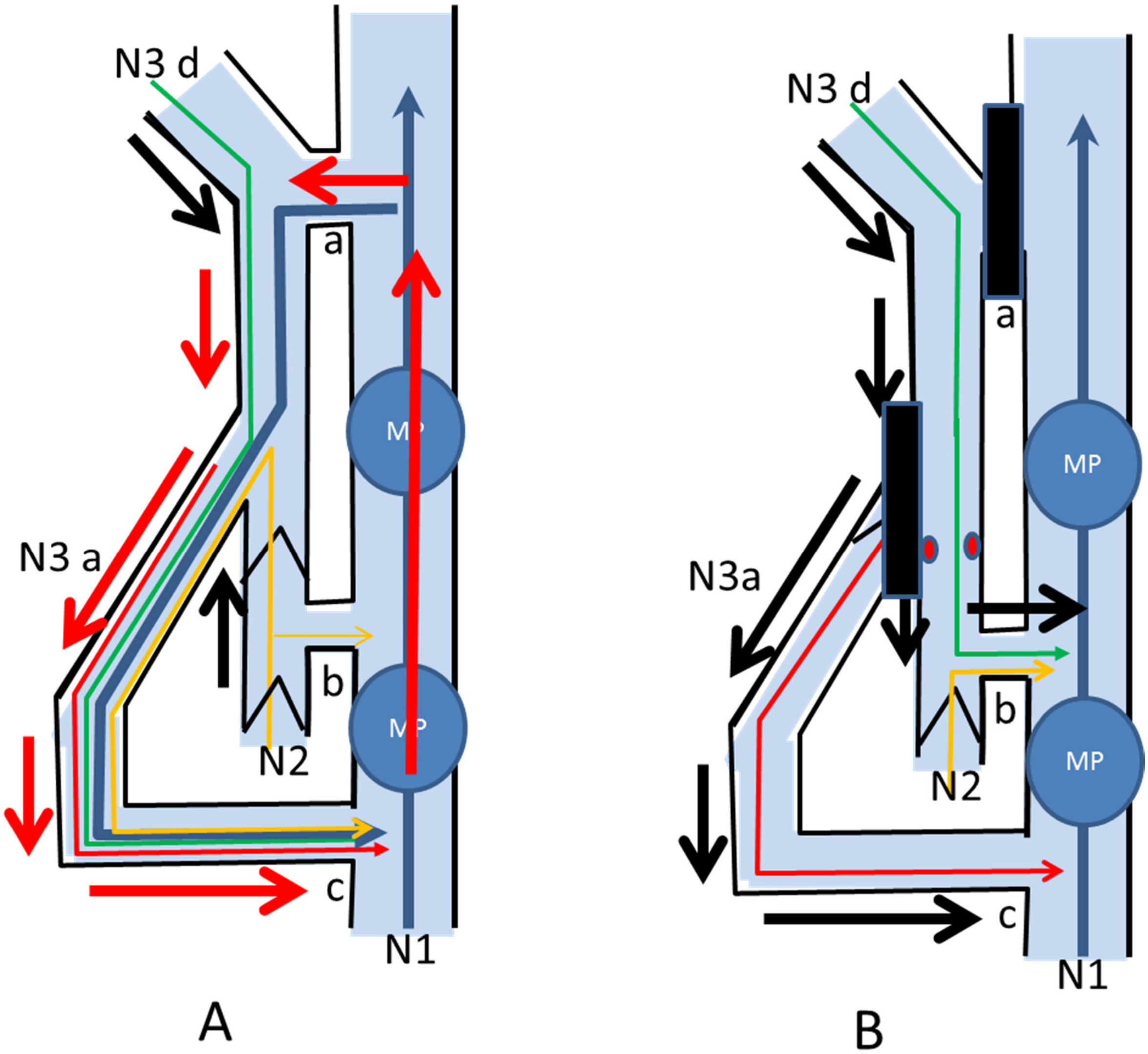

Figure 13 ter. Closed shunt 3 management
N1: deep veins , N2: Saphenous trunks and arches, N3a: ascending tributaries, N3d: arches descending tributaries, a: N2-N1 junction (here SFJ) , b: N2-N1 perforator, c: N3-N1 perforator, MP: muscular pump, o:obstacle.Black arrow: Normal outflow whatever the direction, Red arrow: Overloaded flow whatever the direction. Red line: normal N3a outflow whatever the direction, Green line: Normal N3d outflow the direction, Yellow line: Normal GSV outflow whatever the direction , Blue line: Deep venous outflow
Shunt 3 One step procedure: valve intra-operative destruction combined at the same time with N1>2 and N2>N3 disconnection + leads to B: Shunt 0 (“physiological” reflux) in treated N3 .

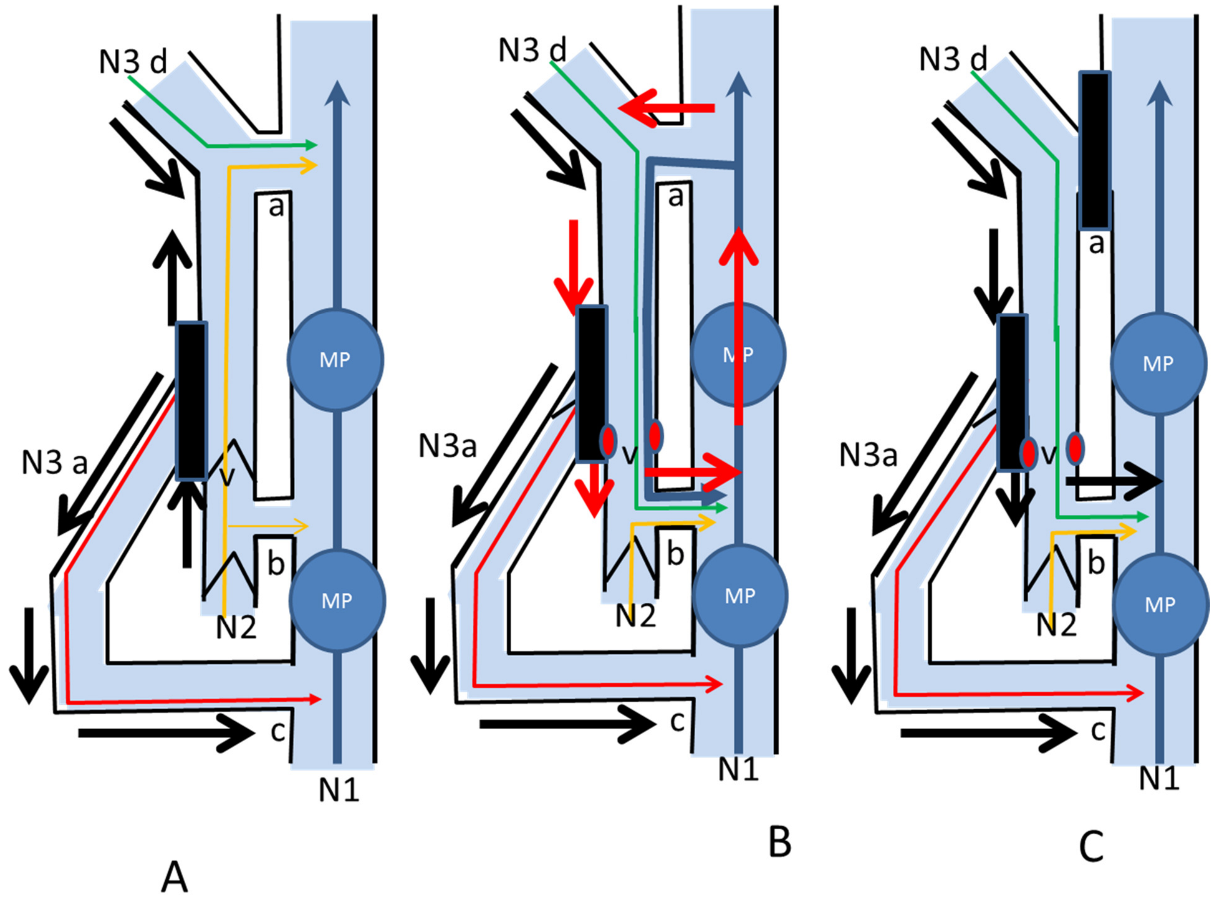

Figure 14. Open deviated shunt (ODS) : Shunt 2. VALSALVA NEGATIVE
N1: deep veins , N2: Saphenous trunks and arches, N3a: ascending tributaries, N3d: arches descending tributaries, a: N2-N1 junction (here SFJ) , b: N2-N1 perforator, c: N3-N1 perforator, MP: muscular pump, o:obstacle.Black arrow: Normal outflow whatever the direction, Red arrow: Overloaded flow whatever the direction. Red line: normal N3a outflow whatever the direction, Green line: Normal N3d outflow the direction, Yellow line: Normal GSV outflow whatever the direction , Blue line: Deep venous outflow
A: ODS: N3a VALSALVA NEGATIVE ,overloaded by N2 (and normal triburatary N3d . N2 not overloaded (segmental proximal reflux VALSALVA NEGATIVE (SFJ a competent).
B: N2>N3 shunt 2 disconnection d leads to Shunt 0 (“physiological” VALSALVA NEGATIVE and proper territory draining reflux).

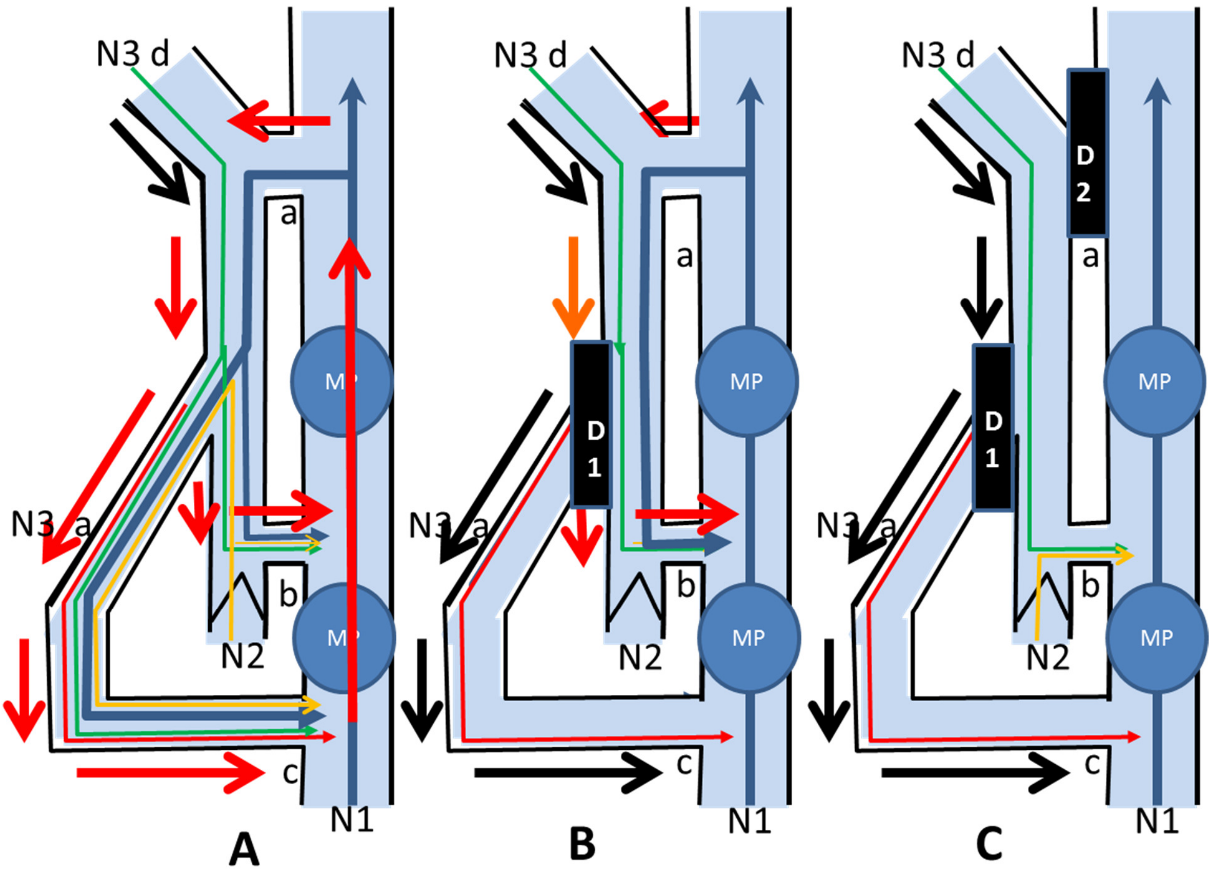

Figure 15. Shunt 1 + Shunt 2 combination
N1: deep veins , N2: Saphenous trunks and arches, N3a: ascending tributaries, N3d: arches descending tributaries, a: N2-N1 junction (here SFJ) , b: N2-N1 perforator, c: N3-N1 perforator, MP: muscular pump, o:obstacle.Black arrow: Normal outflow whatever the direction, Red arrow: Overloaded flow whatever the direction. Red line: normal N3a outflow whatever the direction, Green line: Normal N3d outflow the direction, Yellow line: Normal GSV outflow whatever the direction , Blue line: Deep venous outflow
A: CS SHUNT1 N1>N2>N1 (re-entry b) VALSALVA POSITIVE overloaded by N1. ODS : N2>N3a>N1 (reentry c). VALSALVA POSITVE ,overloaded by N1 + N2 (and normal tributary N3d) .
B: N2>N3 shunt 2 disconnection (D1) : N3a no more overloaded reflux but overlying GHP column not disconnected neither the Shunt1 (risk of recurrence).
C: N1>N2 shunt 1 disconnection
D1 + D2 leads to N2 and N3a Shunts 0 (“physiological” VALSALVA NEGATIVE and proper territory draining reflux).

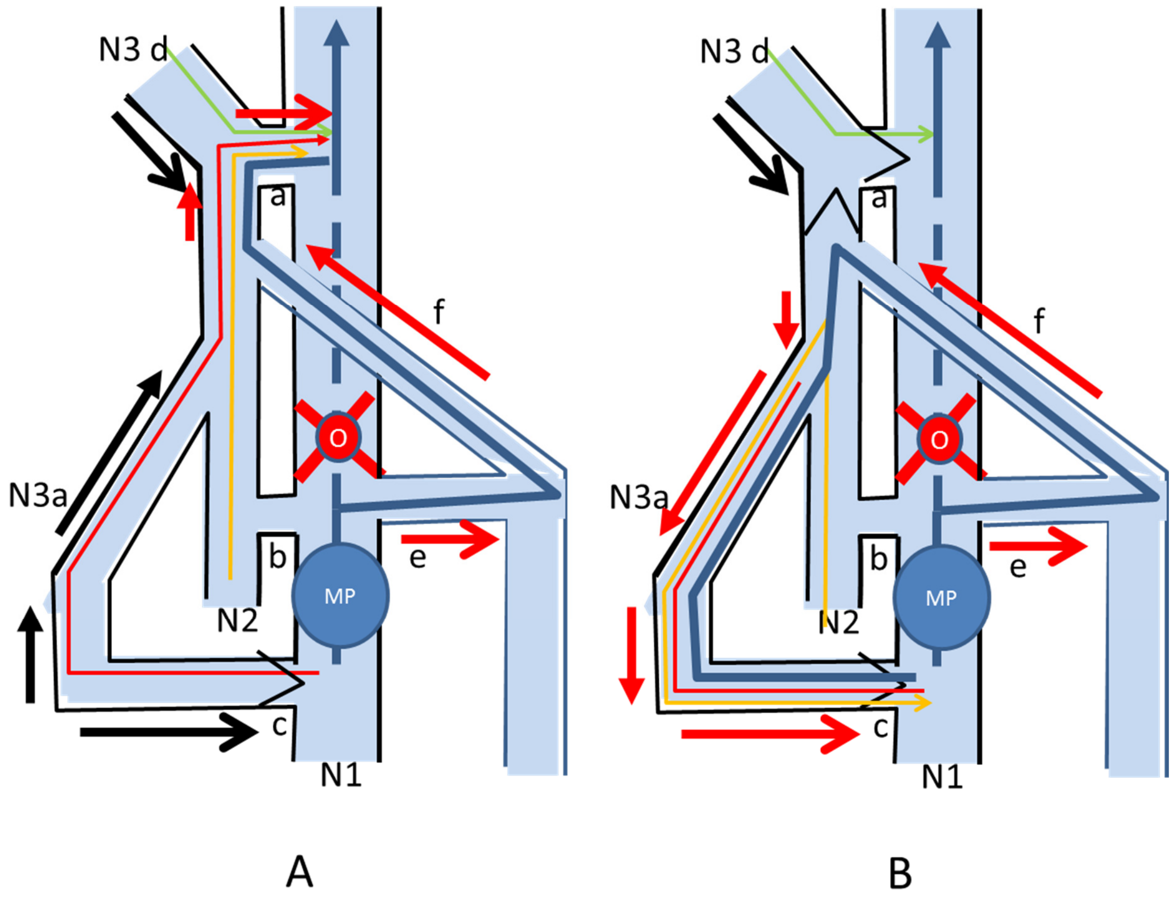

Figure 16. Mixed shunts (MS) : an example of femoral vein obstruction combined with GSV incompetence
N1: deep veins , N2: Saphenous trunks and arches, N3a: ascending tributaries, N3d: arches descending tributaries, a: N2-N1 junction (here SFJ) , b: N2-N1 perforator, c: N3-N1 perforator, e: SPJ, f: Giacomini vein MP: muscular pump, o:obstacle.Black arrow: Normal outflow whatever the direction, Red arrow: Overloaded flow whatever the direction. Red line: normal N3a outflow whatever the direction, Green line: Normal N3d outflow the direction, Yellow line: Normal GSV outflow whatever is direction , Blue line: Deep venous outflow
A: MP systole: OVS activated. obstacle to the flow (O) (here femoral vein) , Open Vicarious Shunt (N1> refluxing perforator c > antegrade N2 (GSV and SFJ) re-entry a but overloaded by N1flow.
B:MP diastole: CS type 3 activated. N1>N2>N3>N1. obstacle to the flow (O) (here iliac vein) , Open Vicarious Shunt (N1> refluxing SFJ and N3d d overloaded by N1, N3a and N2), re-entry >N1 not designed (can be through the antegrade opposite GS arch and SFJ then into the opposite femoral vein.

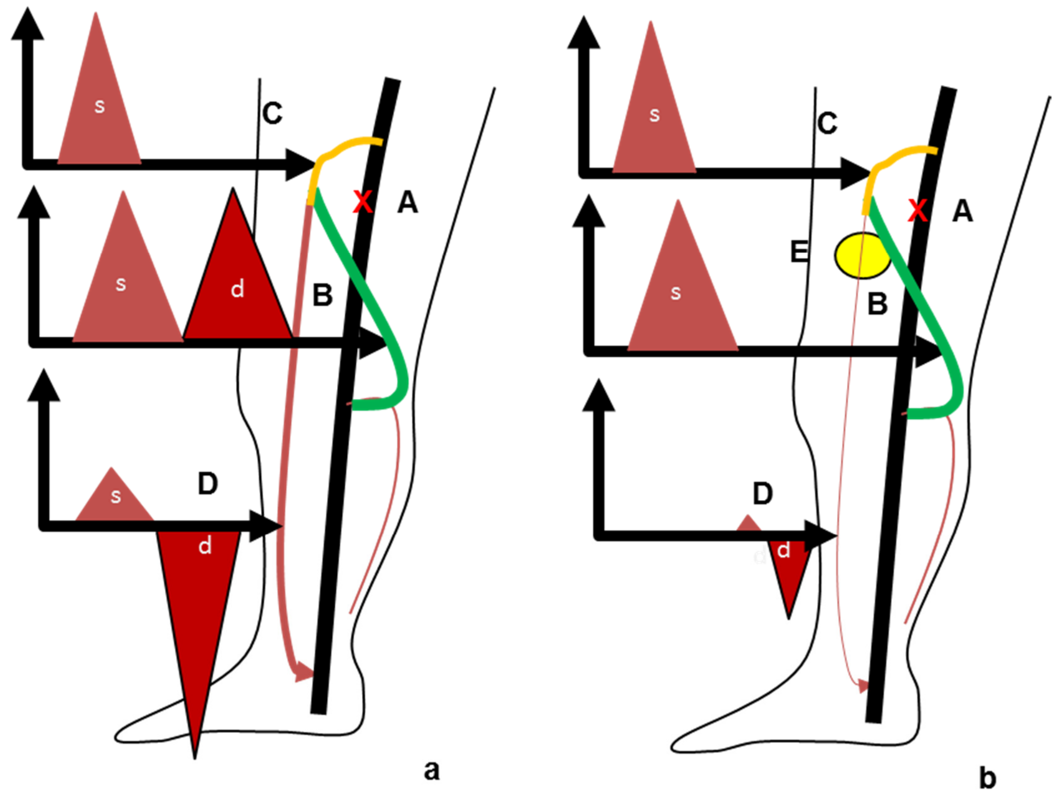

Figure16 bis : Mixed shunt: an example of femoral vein obstruction combined with GSV incompetence
s: systolic flow, d : diastolic flow
a: A: femoral vein hemodynamic obstacle (not necessarly obstruction) , B: common escape point (SPJ) , SSV arch and Giacomini vin to the OVS and CS, C: OVS branch (GSV arch SFJ) where it drains into the common femoral vein during the systole. D: Diastolic reflux of the CS branche made of the GSV trunk. CS
b: changes after the GSV trunk disconnected below the arch (E). The CS branch is diconnected and the reflux is shunt 0. The OVS is preserved and continues to by-pass A.

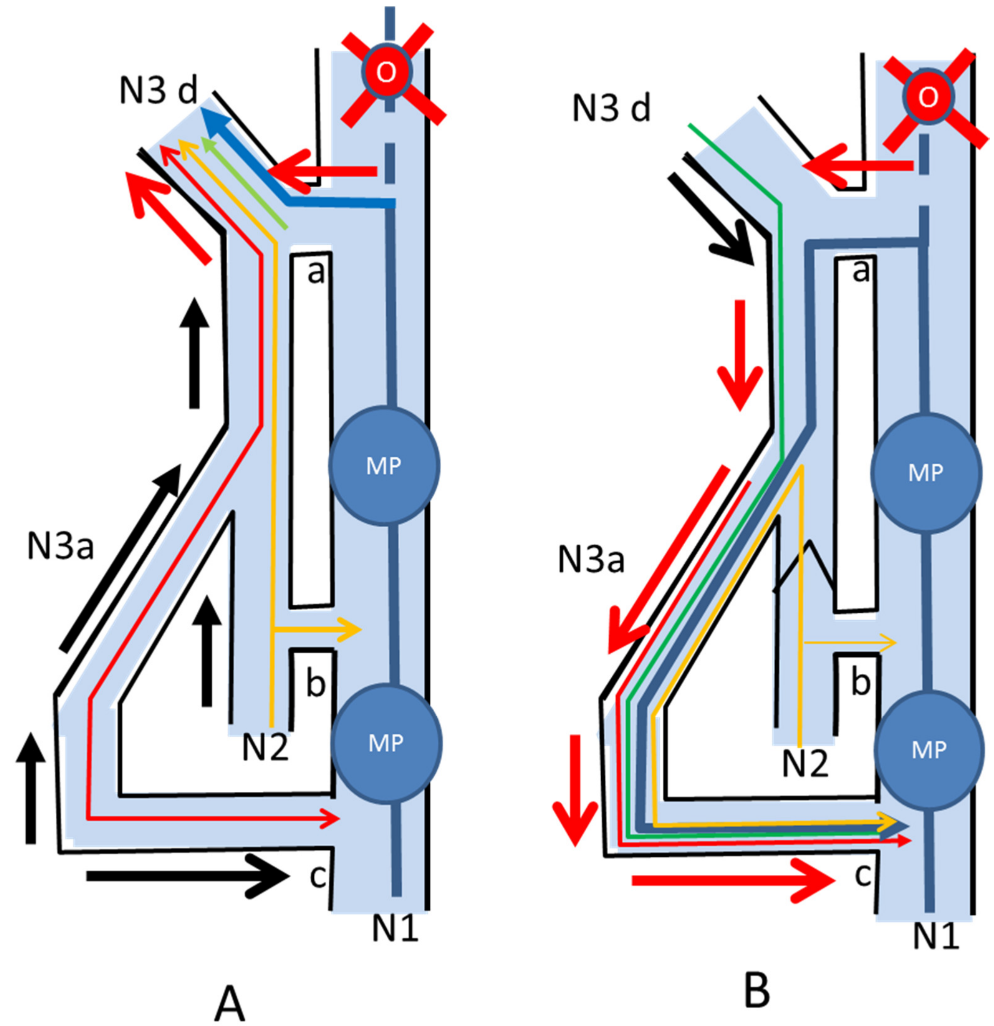

Fig 17 Mixed shunts (MS) : an example of ILIAC vein obstruction combined with GSV incompetence

N1: deep veins , N2: Saphenous trunks and arches, N3a: ascending tributaries, N3d: arches descending tributaries, a: N2-N1 junction (here SFJ) , b: N2-N1 perforator, c: N3-N1 perforator, MP: muscular pump, o:obstacle.Black arrow: Normal outflow whatever the direction, Red arrow: Overloaded flow whatever the direction. Red line: normal N3a outflow whatever the direction, Green line: Normal N3d outflow the direction, Yellow line: Normal GSV outflow whatever the direction , Blue line: Deep venous outflow Iliac vein obstacle O. GSV varicosis.
A: MP systole: OVS activated. obstacle to the flow (O) (here iliac vein) , Open Vicarious Shunt (N1> refluxing SFJ and N3d d overloaded by N1, N3a and N2), re-entry >N1 not designed (can be through the antegrade opposite GS arch and SFJ then into the opposite femoral vein.
B: MP diastole: CS type 3 activated. N1>N2>N3>N1. . Here N1 overloading SFJ a (escape point) > Arch and GSV refluxing down into a refluxing tributary N3 then to antegrade re-entry perforator c then into N1
In MS, OVS and CS have the same escape point (here SFJ) and a common proximal refluxing pathway (here the arch) but their distal segment and re-entry are different : N3d up to the opposite femoral vein for the OVS and N2>N3 down to perforator c for CS.

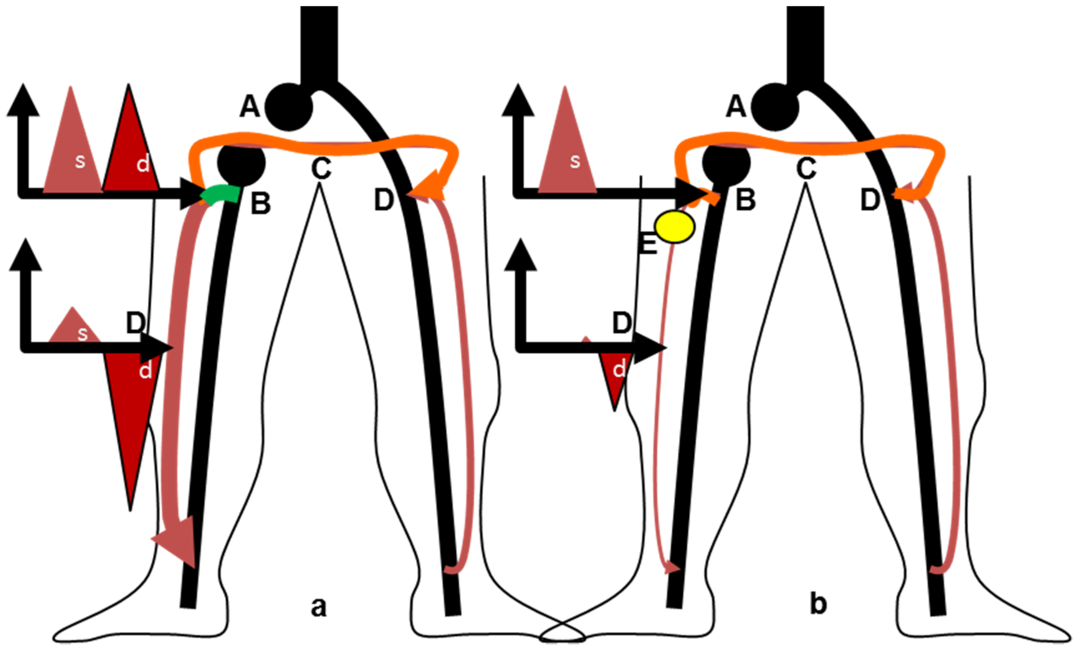

Figure17 bis: Mixed shunt: an example of Iliac veine obstruction combined with GSV incompetence

s: systolic flow, d : diastolic flow

a: A: Right iliac vein obstruction , B: common escape point (SFJ) and GSV arch to the OVS and CS, C: OVS branch (Spontaneous palma) to the opposite GSV arch SFJ D where it drains into the common femoral vein during the systole. D: Diastolic reflux of the CS branche made of the GSV trunk. CS

b: changes after the GSV trunk disconnected below the arch (E). The CS branch is diconnected and the reflux is shunt 0. The OVS is preserved and continues to by-pass A.

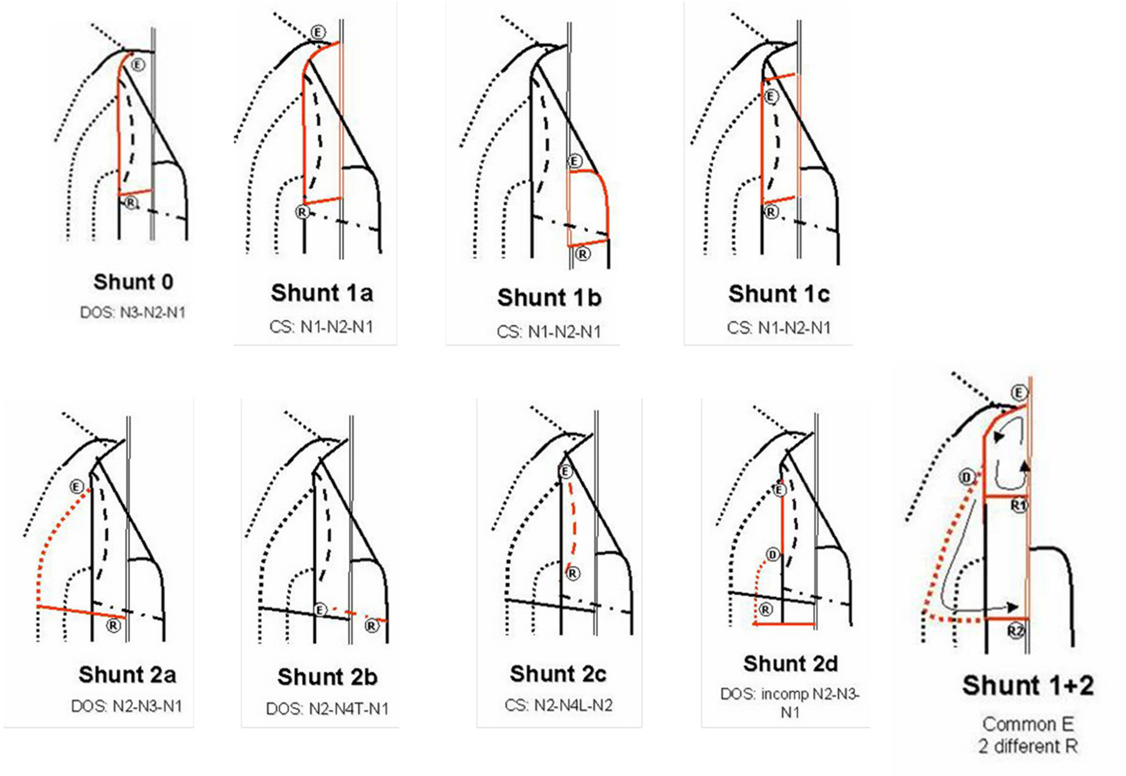

FIG 18: Teupitz Shunts classification : shunts 0, 2 , 3 and 1+2

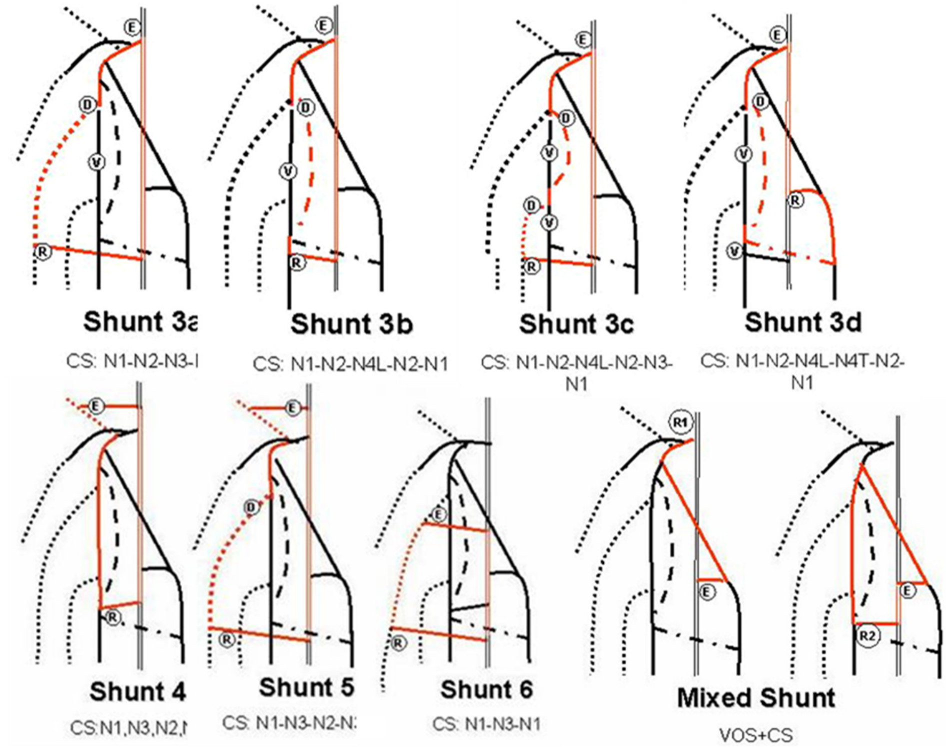

FIG 19: Teupitz Shunts classification : shunts 3,4,5,6 and mixed shunts

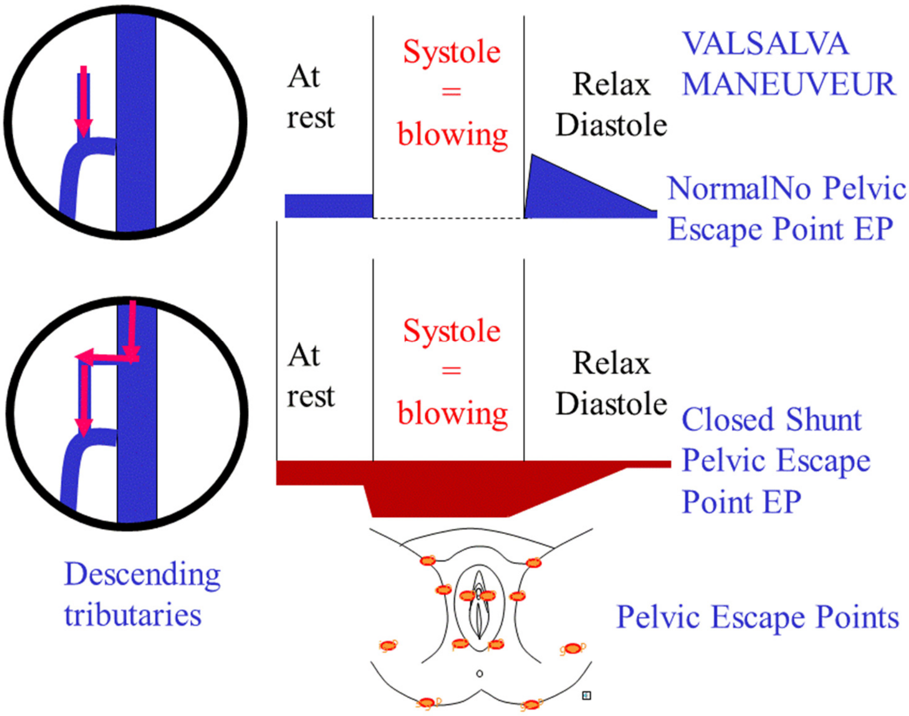

FIG 2O: Valsalva Maneuver in descending tributaries of the GSV arch: Pelvic escape points