4 - Reflux patterns and Types of shunts

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https://doi.org/10.5281/zenodo.6490674

Key Points
Not all reflux saphenous vein needs intervention
Discussion of Reflux theories
Explanation of Shunts (basis for CHIVA operations)
Waveform analysis

The good understanding of reflux theories and the origin of the flow problem of each patient is important to surgeons that perform procedures preserving the saphenous vein. This chapter is probably the most important chapter of this book. Once the reader can see the reflux from a Shunt point of view, it turns the saphenous preserving mentality on. Franceschi et al. published the concept of shunt in 1988 [1]. A venous shunt considers the anatomical compartments (N1-deep, N2 - saphenous, N3 - collateral). There is a usual flow direction and volume in every vein, they follow the venous hierarchy. A shunt is a break in this hierarchy.

The shunt usually has 3 characteristics, (1) an exit - escape point, (2) pathway - involved veins with reflux and (3) a re-entry for the blood. Thus, the escape point is the “short circuit” that provides pathological deviated blood to overload the involved veins. The veins that carry this overloaded blood are the pathway. Finally, the re-entry is the vein that carries the blood back to the right track. The re-entry is as important as the other parts of the shunt, and sometimes forgotten. I would like the reader to imagine what would happen if the blood left the deep system, ran through an extensive set of veins in the leg and did not have a way back to the deep system/heart. I can only imagine a superficial thrombosis happening on the first day. So, when you think of a shunt, always think of the escape, the pathway and the re-entry.

Reflux is a complicated subject, and there is no single cause to blame for it. Its origins and classification are very debatable. This shunt theory includes most cases of varicose patients, but we often see cases of reflux that did not have an obvious escape point from the deep system. For example, varicose veins that occur after dilation of subcutaneous veins that get together to create a reservoir and overflow creates reflux.

We will discuss the shunts one by one in this chapter. We present now one simple example of shunt to entice the memory. The great saphenous vein at the femoral junction has important reflux (escape point) from the junction to the low-thigh and drains to a dilated collateral (pathway). This collateral after a few centimeters of dilations drains its blood to a perforator that drains its reflux (re-entry). The perforator drains to the tibial vein, and the blood goes back to where it belongs.

Reflux Theories

This book has a chapter about physics and hemodynamic principles. The knowledge of a few principles is pivotal and will be briefly presented. The gradient is the difference of energy between 2 recipients (or venous systems). If there is a communication - no valve - the energy tends to go from the high energy to low energy until it is equal in both sides. The energy depends on the gravity and the size of the blood column. Bernoulli stated that the flow velocity creates a differential pressure because of the difference in the lateral pressure on the vessel. The faster the flow, the smaller the lateral pressure and the easier for the blood to go from one vein to the other. This is important, if the vein dilates, the velocity decreases and the lateral pressure increases, making it more difficult for the blood to get in that vein. Venturi described a tendency for faster flow in a stenosis, to help blood get inside a vessel. Poiseuille stated that turbulence creates dilation of the vein (why do venous grafts dilate less in a high-pressure arterial bypass than in a lower pressure venous system?). The thoracic abdominal pumps and calf muscle create a constant turbulence in leg veins. The veins are compliant, which means they increase the blood reservoirs before an increase in pressure. The smaller the vein, the higher the compliance and capacity to become a reservoir of blood and dilate. The Laplace law states that the higher the radius, the higher the pressure in the wall of a vein.

There are two basic theories on the origin of reflux. The ascending theory considers that the varicose veins dilate at the epifascial veins or smaller ones [2]. This increases the compliance of these veins and, according to the Venturi effect, these veins present turbulent flow. Oscillatory turbulent flow is one of the major causes of venous deterioration [3,4]. Studies have also shown that even micro-veins have valves, and these relate to the skin degeneration of chronic venous insufficiency [5]. This theory relates to the cases in which we observe a reflux only at the superficial system. The descending theory considers that the distinct pressures between compartments (deep-superficial, saphenous-epifascial) creates unbalances and consequently a gradient. This gradient sends flow from one system to another in certain circumstances. The abdominal-thoracic pump forces blood down during Valsalva maneuver, and the leg muscles pump blood up during contraction (systole). If an abnormal connection (valveless saphenous junction, perforator, pelvic leak or other source) is present, the pumped blood will search to fill the gradient of the system with less pressure.

Both theories explain part of the cases, and the authors consider that ascending and descending theories are complementary. We see patients with superficial-only varicose veins, unrelated to the deep system or saphenous system. For example, patients with lateral thigh collaterals and telangiectasias that descend laterally and drain its reflux to a perforator or the distal saphenous vein. Evidence suggests that the micro-veins have valves and relate to reflux and skin alterations of chronic venous disease [5,6]. Patients that activate a pelvic shunt after pregnancy are a typical example of the descending theory.

Is Reflux Always Pathologic? No.

The widespread use of duplex scan has created many diagnoses of reflux. The effect of this was that we turned people into patients. We can provoke flash reflux in many people with normal legs. Following the guidelines for duplex evaluation avoids wrong reflux diagnosis, i.e. patient standing during examination. Many patients with leg pain search for help with vascular surgeons. There are several diseases that cause leg pain mimicking the pain of venous disease, i.e. orthopedic, neurologic, rheumatic and so on. If a rushed medical interview and clinical examination misses the other disease and the patient has an asymptomatic reflux in the duplex scan, the practitioner might perform an unnecessary procedure. Unfortunately, this is much more common than we desire. Even in those cases, with minor symptoms or esthetic complaints related to a reflux, we should remember that an intervention is not the only way. There are at least two recent editorials of important vascular/Phlebology journals in Europe and America that address the overtreatment situation [7,8]. Lawrence and Gloviczki addressed the overtreatment situation deeply and proposed that the medical societies should educate its members and that insurers should increase their oversight [7]. Campbell et al. suggests we should provide the patient a well-informed choice (including an understanding of the consequences of no treatment) [8]. We need to remember that not all reflux relates to a venous disease, and that not all symptoms in the leg relate to venous reflux.

Classification of Shunts

Open versus Closed Shunts and Mixed Shunts.

The classification of shunts proposed by Franceschi bases on the characteristics of the escape point, pathway and reentry point. The shunt is closed if it recirculates in a closed circle. For instance, the reflux escapes at the saphenous-femoral junction, making its way through the saphenous vein until it gets to a perforator and enters the deep system. The blood passes at the femoral junction again. Basically, the closed shunt re-circles at the same vein where it started. We consider the shunt open if it does not re-circle in the same vein before it goes to the heart. An example of open shunt would be a Palma bypass, the flow escaping at the left saphenous-femoral junction goes to a collateral pathway and finally re-enters at the right saphenous-femoral junction. The blood will not re-circle its origin, being considered an open shunt. Mixed shunts are those that have an open shunt and a closed shunt that share the escape point and part of the pathway. As an example, let us add up the examples before. The patient with a left-right Palma bypass after iliac obstruction develops dilation and reflux at the left saphenous vein in the compensation process. This patient will have a mixed shunt, one open and one closed with the escape point at the saphenous-femoral junction and part of the left saphenous vein in common.

The Concept of Vicarious and Derived Shunts

The Vicarious shunts are the shunts that divert blood from an obstruction (deep thrombosis, trauma) to compensate it. The term vicarious shunt was used to describe a bypass shunt, a bridging circulation or a circulation by proxy. This shunt has an obstruction and expresses usually by systolic flow. The leg muscles pump the blood up to the heart and the blood finds an obstruction, then it directs to the proxy circulation to finish its pathway. The development of superficial varicose veins and telangiectasia after saphenous ablation or saphenectomy is also a vicarious shunt; we destroy the pathway of the blood, whether it is up to the junction or down to a perforator. The reaction is to develop increased pressure and create new collaterals.

The derived shunts (deviation or detour shunts) deviate the flow from the escape point to the pathway and re-entry points.

The derived shunt is the consequence of valve incompetence at an anatomical position that allows gradient pressure reversion to enter the shunt. These shunts have diastolic reflux predominantly. This means that after muscle contraction that increases pressure on the leg veins comes the relaxation that decreases it. This relaxation allows reflux to go back through the escape point and nurtures the derived shunt. The concept of systole and diastole and inward and outward flow is essential and will come later in this chapter. If we see an outward systolic flow automatically, we should think of deep disease and evaluate the case in its complexity.

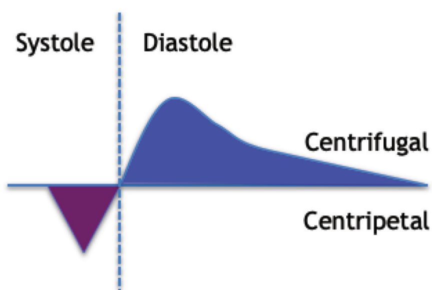
The Phases of Reflux (Waveform Analysis).

The pulsed wave of color Doppler can help us understand the physiology and pathology of the flow. We need to observe the usual aspects most readers already know about, upward versus downward flow. This means the time and speed of flow/reflux. All guidelines discuss the time of reflux we need to consider reflux pathologic. The speed is also obvious, and most doctors recognize that a higher speed means worse reflux. The model of time of reflux is to define pathologic reflux is not perfect. The time depends on the dynamics of the maneuver, the greater the emptying of the leg, the greater the reflux (see dynamic maneuvers in this chapter).

The knowledge of venous compartments is essential to understand venous disease. It is important to know from where to where the blood is moving to comprehend the pathologic mechanism involved and treat it. We should analyse the inward and outward flow between compartments, besides upward and downward. When there is a connection of two compartments, i.e. N1 (Deep) with N2 (Saphenous Vein), we should profit from the opportunity and go beyond measuring speed and velocity. Looking at the wave of reflux, we can understand the direction of flow and correlate with the stimuli that is creating that flow.

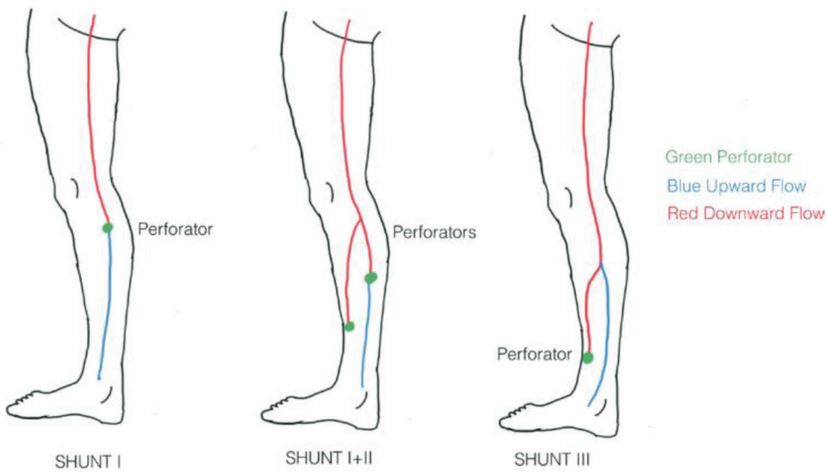
The Valsalva maneuver forces blood out of the abdomen. The systolic phase (blowing out) increases abdominal pressure, and the diastolic phase (breathing in) decreases it. During the systole it forces the blood down to the leg and to the pelvic veins unless valves stop it, and during the diastole it aspirates the blood back to the abdomen. The contraction of calf muscles does the opposite. The systole of this maneuver forces blood into the abdomen, and the diastole aspirates blood back to the leg unless valves stop it.

The characteristics of the flow can help us understand the disease and provide adequate hemodynamic treatment. If you analyze, the flow at the waveform figure during a maneuver, you will have the systole, diastole and according to the transducer position, you can infer if the flow is centrifugal or centripetal. For example, if you consider a dynamic maneuver contracting the calf muscles, the figure will represent the following: 1) The systole (muscle contraction) creates flow from the leg to the heart. 2) The diastole (muscle relaxation) creates flow/reflux from the heart to the leg.



The Classification of Shunts and Types of Shunts

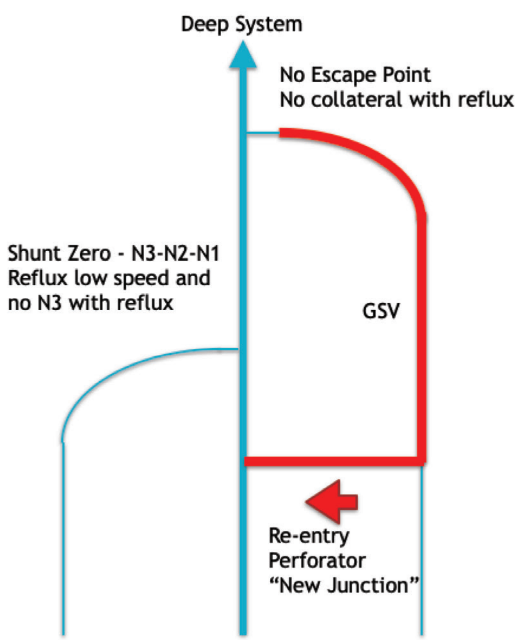
There are basically 3 types of shunts according to draining perforators. Shunt type I perforator drains reflux directly from the saphenous vein. Shunt type II is collateral to perforator. Shunt type I+II has a perforator draining the saphenous vein and another draining the collateral. Shunt type III has saphenous reflux that does not have a saphenous perforator, it drains to a perforator in a collateral. The last type poses difficulty to simple CHIVA procedures. The figure shows the easy to memorize shunt to guide the first approach. Later we show the complete shunt classification of CHIVA.



We present the full classification of closed shunts below. It divides the closed shunts according to Escape point, pathway and re-entry. The most important aspect you should observe is the re-entry, whether it is in a perforator from the saphenous veins or a perforator from a collateral N3.

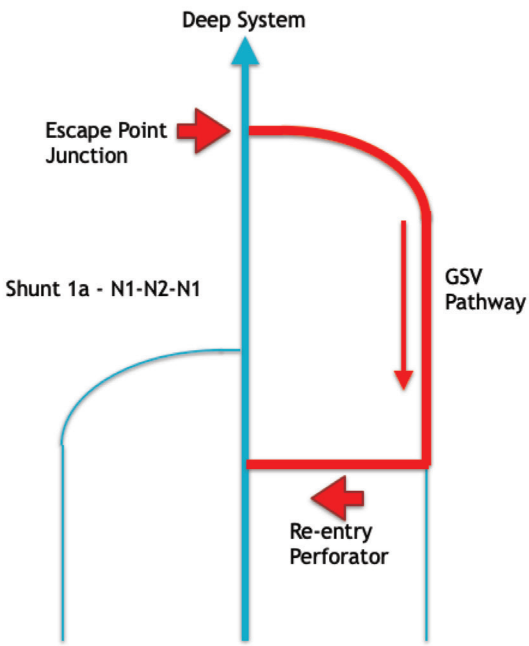
Shunt Type Zero

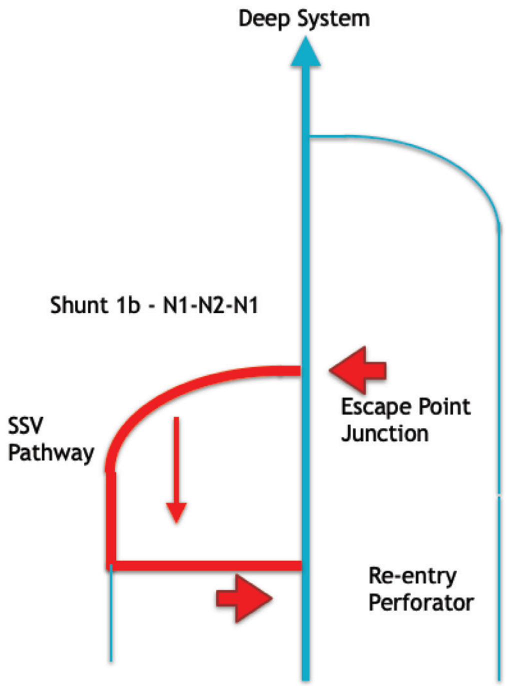
The concept of Shunt zero is pivotal. It is the ultimate result of a well done CHIVA operation or a physiologic reflux that does not need treatment. Shunt zero is a centrifugal flow at the saphenous vein characterized by “reflux” at the duplex scan. The flow has low speed and drained to a perforator. If a N3 collateral presents significant reflux it is not a shunt zero. The flow does not change the compartment N2. This shunt is the final result of CHIVA when the saphenous flow cannot be reversed. This concept is also important for surgeons of other non-preserving techniques, as this physiologic flow should not be treated. Unfortunately, we have seen many patients with shunt zero reflux having their saphenous veins ablated.

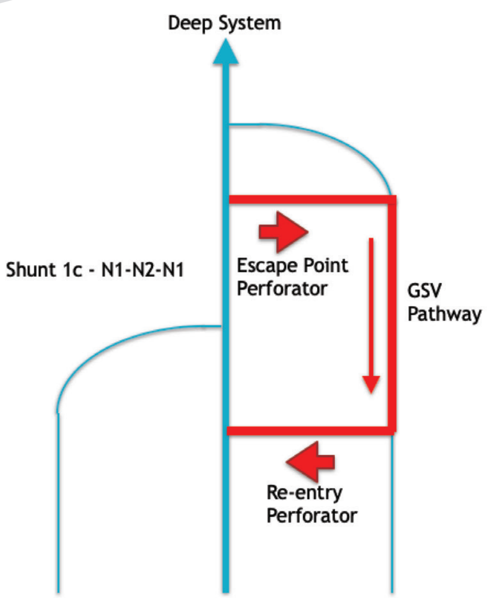


Shunt Type 1

The escape point is located at a junction or perforator straight to the saphenous vein (Saphenofemoral, perforator or saphenopopliteal), the pathway is exclusively saphenous and the drainage (re-entry) is a perforator directly from the saphenous vein involved. These cases have no reflux at N3 collaterals.

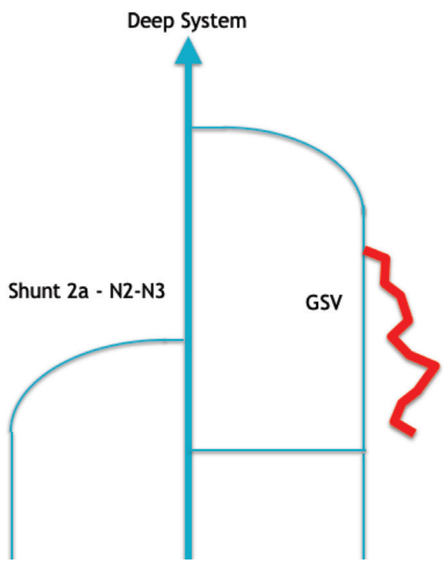


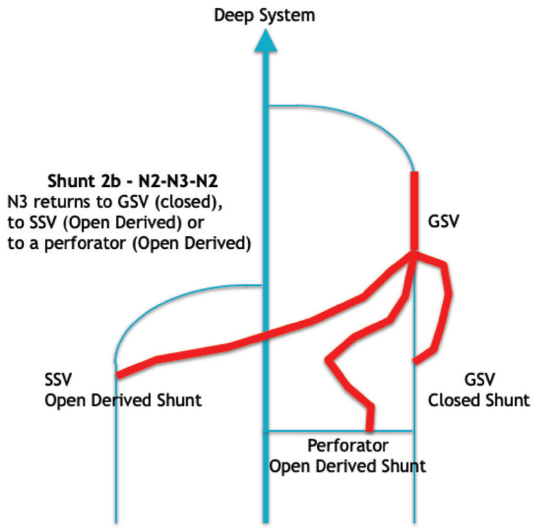

Deep System
Shunt 1b - N1-N2-N1
SSV
Pathway
Escape Point
Junction
Re-entry
Perforator

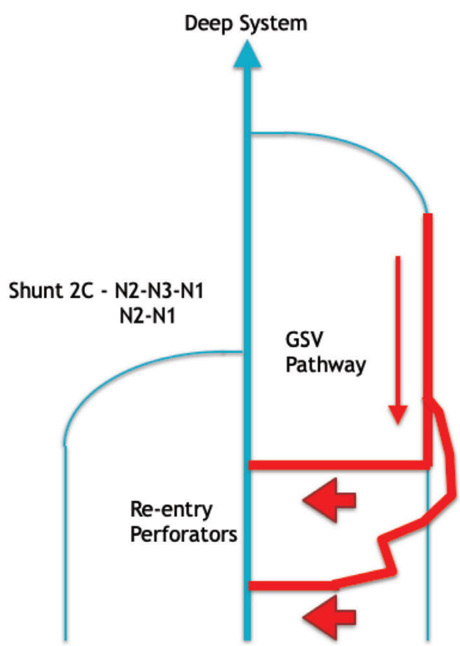

Deep System
Shunt 1c - N1-N2-N1
Escape Point
Perforator
GSV
Pathway
Re-entry
Perforator

Shunt Type 2

There is no definite escape point from the deep system. The change of compartment is from N2 saphenous vein to N3 collateral vein. The pathway is a collateral and the re-entry may be at the saphenous veins or a perforator.

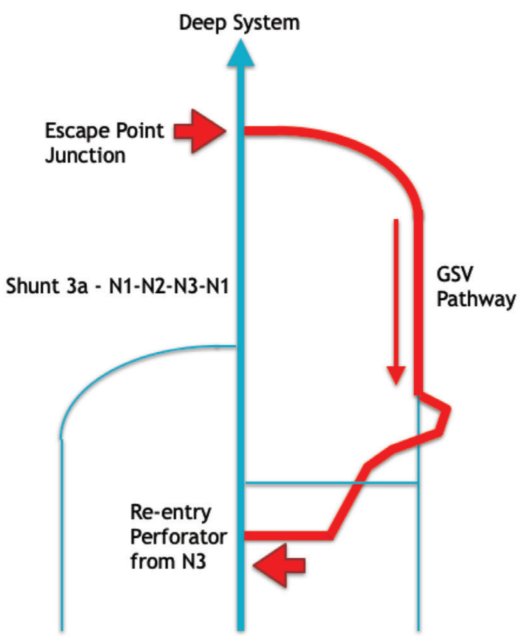


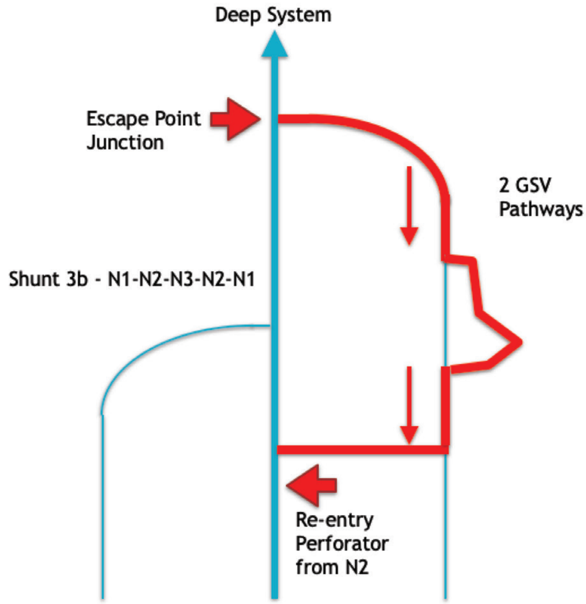

Deep System
Shunt 2b - N2-N3-N2
N3 returns to GSV (closed),
to SSV (Open Derived) or
to a perforator (Open Derived)
GSV
SSV
Open Derived Shunt
GSV
Closed Shunt
Perforator
Open Derived Shunt

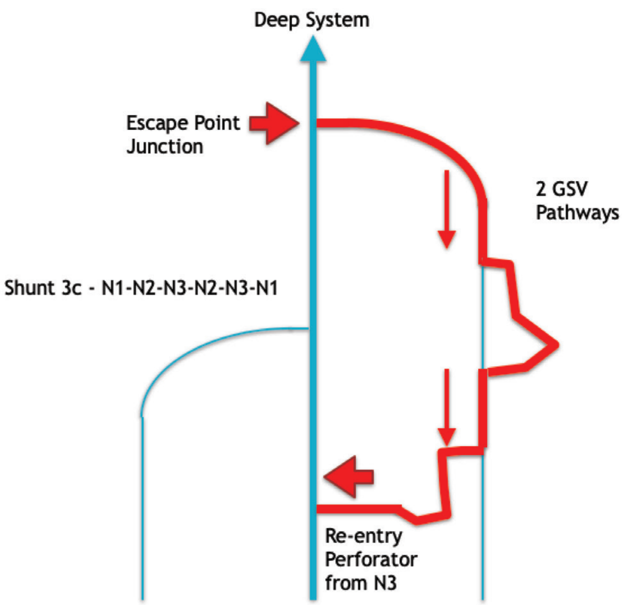

Deep System
Shunt 2C - N2-N3-N1
N2-N1
GSV
Pathway
Re-entry
Perforators

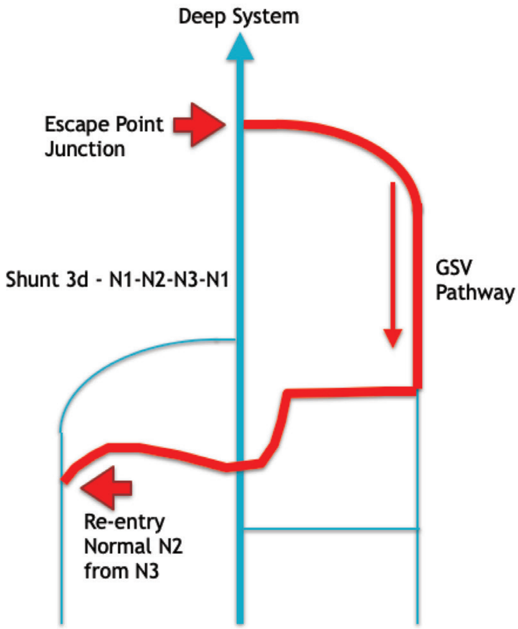
Shunt Type 3

There is an escape point from the deep system (junction) and the pathway includes the saphenous vein and a collateral. The re-entry is a perforator or the other normal saphenous vein. There is no perforator directly connected to the saphenous vein with reflux, the perforator is connected to the collateral only or to the other saphenous vein (for example, great saphenous vein with reflux, reentry at the small saphenous vein).



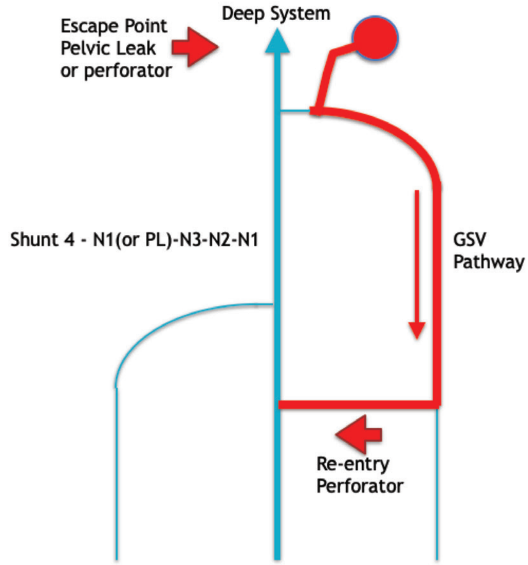

Deep System
Escape Point Junction
2 GSV Pathways
Shunt 3b - N1-N2-N3-N2-N1
Re-entry Perforator from N2


Deep System
Escape Point Junction
2 GSV Pathways
Shunt 3c - N1-N2-N3-N2-N3-N1
Re-entry Perforator from N3



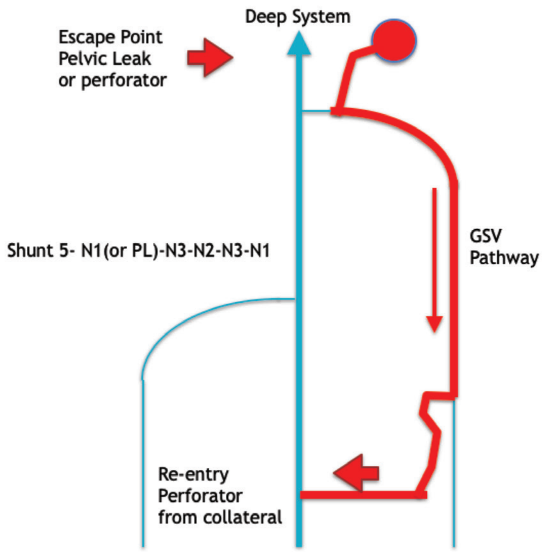
Shunt Type 4

The escape point is a pelvic leak or a perforator that uses the saphenous vein as a pathway. The first saphenous valve must be without reflux. The re-entry point is a perforator directly from the saphenous vein to the deep system.



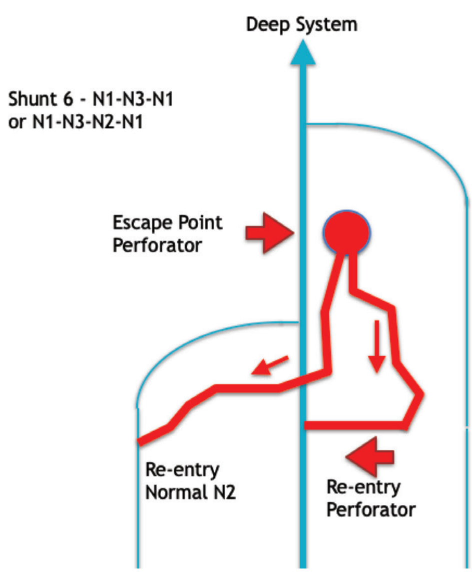
Shunt Type 5

The escape point is a pelvic leak or a perforator that uses the saphenous vein as a pathway. The first saphenous valve must be without reflux. The re-entry point is a perforator from a N3 collateral to the deep system.



Shunt Type 6

The escape point is a perforator draining to a collateral. This collateral N3 is the pathway and drains to another perforator or a normal saphenous vein without reflux.



Dynamic evaluation of reflux

There are two basic tests for reflux considering the effects of breathing and leg muscles in the venous system: The Valsalva and the calf squeezing maneuvers. The squeezing test is made by distal compression of the calf, achieved by manual or cuff compression [9,10]. This maneuver has some flaws that make us look for better and more physiological alternatives. Patients with leg edema and pain usually get uncomfortable during the examination. Patients with large calves, ulcers and doctors with smaller hands also present as problems to examine reflux adequately. The compression created manually or cuff is not physiological and might create undesirable breaking of the flow in non-physiological compartments (you may press one muscle harder than another). This may mislead us sometimes when we think we have produced flow in a specific area and in reality we have not. The lack of a standardized method for compression makes reproducibility difficult [10]. Thus, we consider new and more physiological alternatives to the squeezing are desirable.

The Parana Maneuver creates a physiological upward flow by simultaneous contraction of most leg muscles. This effect is achieved by a push or pull at the waist, depending on the patient's position towards the examiner [11]. This maneuver creates a higher flow than squeezing and contracts all muscles physiologically. It is widely used in venous hemodynamic examinations. The Parana Maneuver is easy to perform when the patient's back is facing the examiner. When the patient is facing the examiner the maneuver is a push at the waist that is not comfortable for the doctor. We developed another maneuver easier to do in this position, but the validity is not published yet. Thus, our discussion in this chapter focuses on Paranà Maneuver. There is another maneuver constantly used that mimics calf contraction and is sometimes easier to perform than the Paraná maneuver. The Knee bending maneuver was created by Stefano Ermini during a temporary physical difficulty to perform Paraná. The physician pulls the leg to force calf contraction with one hand and performs the duplex with the other. This maneuver makes it easier to finger press and close a collateral during the maneuver and test reflux, it also avoids compression at the leg that is favorable for patients with painful edema. This maneuver is currently under validation by the authors of this chapter.

QR code to Knee Bending maneuver.

The Paranà Maneuver moves 68% more blood than the Squeezing Maneuver, it doubles the time of diastolic phase in patients with incompetence of saphenous vein and triples in perforators [11]. All the chapters discussing hemodynamic reflux and treatments in this book consider Paranà and Valsalva. We perform squeezing tests in the hemodynamic evaluation of our patients to external validity of our reports according to guidelines.

QR Code Parana Meneuver

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