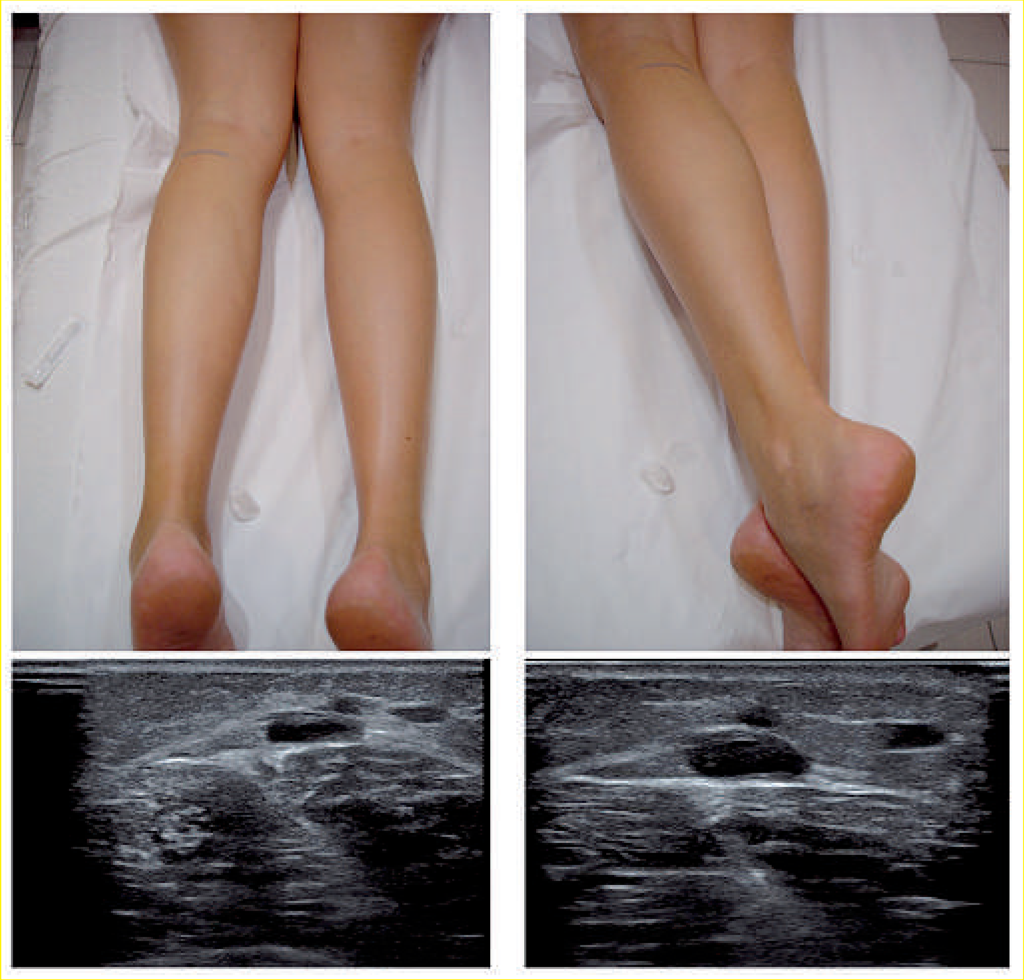


Fig. 31: Placing the instep foot of the leg on the Achilles tendon of the other leg relaxes the muscles and thus allows a better view of the SSV to be injected.

pencil (which writes in the gel) a safe puncture area can be determined.

After checking that there is no artery in the area to be punctured, simply draw a line with the pastel pencil underneath the ultrasound probe **(Fig. 30)**.

Thus, two zones will be delimited: an examination zone and the ultrasound probe will be placed just above the line, and a zone below which will be the puncture zone, which can be disinfected. Thanks to this small means, we will avoid searching, just before the injection for the vein that we had identified before the preparation of the foam.

In a standing position, knees stretched out or in a prone position on the examination bed, the fascia is pulled by the gastrocnemius and hamstring muscles, resulting in compression of the vein.

In order to have a better view of the SSV, these muscles should be relaxed by asking the patient to slightly bend the knees during the examination in the standing position and while lying down, in order before injecting or puncturing the vein, to place the instep of the leg to be treated on the contralateral Achilles tendon **(Fig. 31)**.

Relationship with nerves

Paresthesias after SSV surgery are feared by surgeons. Neurological risks can be either sensitive to paresthesias or motor to steppage type.

The nerves involved are the sciatic nerve, which divides into the anterior tibial nerve and the common fibular nerve, at a variable level above the femoral condyles most often between 3.5 and 5.5 cm above the knee crease, but may have a very high division in the thigh.

This division is always lateralized (external face) most often at about 3.5 cm from the axis of the limb **(Fig. 32)**.

The medial sural nerve originates from the anterior tibial nerve, and the lateral sural nerve from the fibular nerve.

These 2 nerves meet most often (in more than 75% of cases) at the bottom of the calf muscle, and the innervation of these 2 sensory nerves are the lateral surface of the leg and foot, with a maximum area of hypoesthesia, ellipsoid, below the lateral malleolus.

Today, high-frequency probes (at least 14 MHz) can detect all nerves [24, 25]. In the popliteal fossa, the anterior tibial nerve and the fibular nerve are still visible

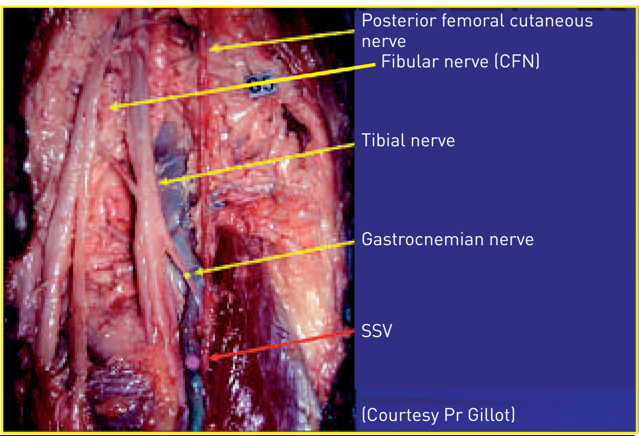


Fig. 32: Anatomical view (Pr Gillot): The posterior femoral-cutaneous nerve of the thigh is exactly in the midline with the limb. Division of the sciatic nerve is usually lateralized 3.5 cm from this axis.

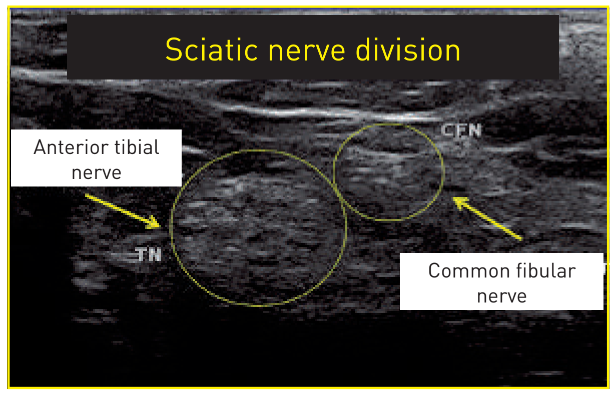
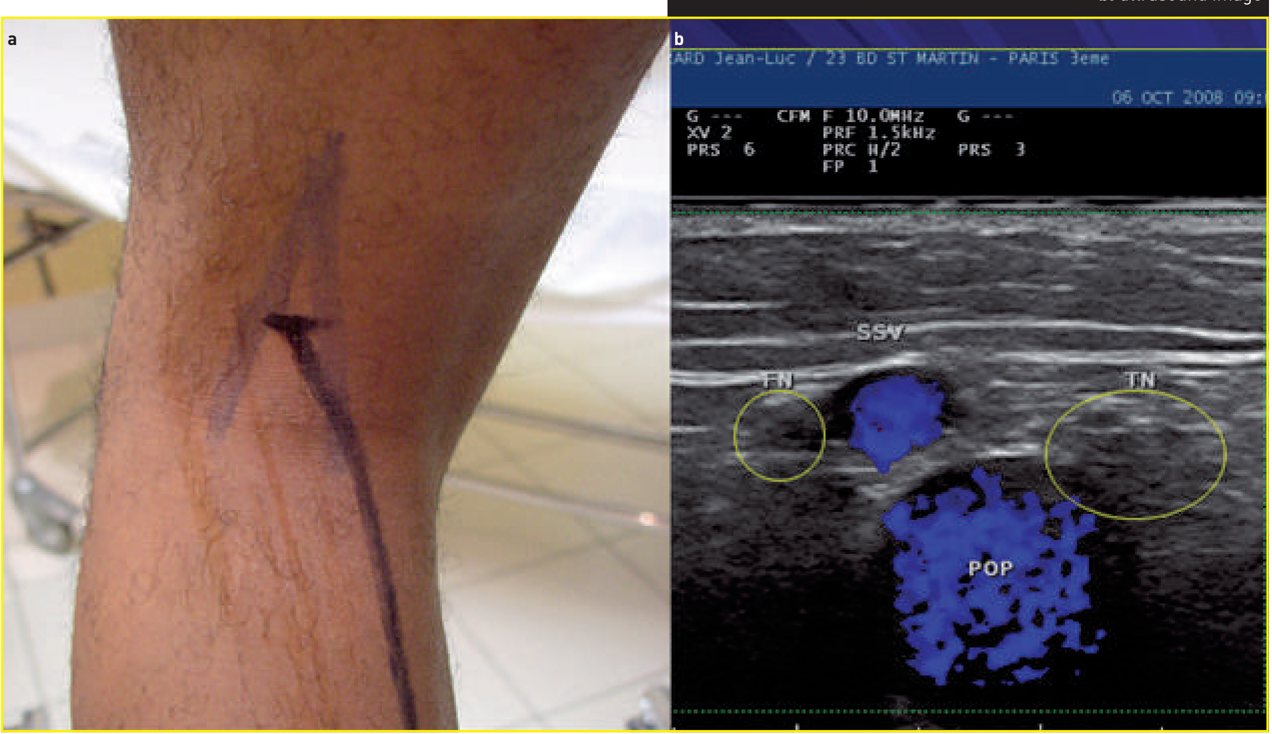


Fig. 33: Honeycomb image of nerves.

Fig. 34 ab: Example of SSV termination, top located and lateralized. **a:** mapping the SSV termination (black felt pen) and mapping the sciatic nerve division (blue felt pen). **b:** ultrasound image



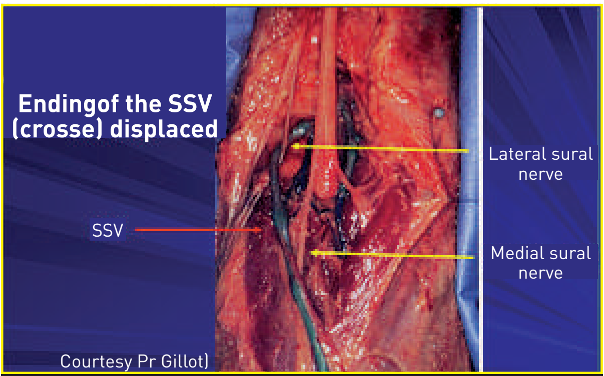


Fig. 35: Termination of lateralized SSV by hooking the sural nerve.

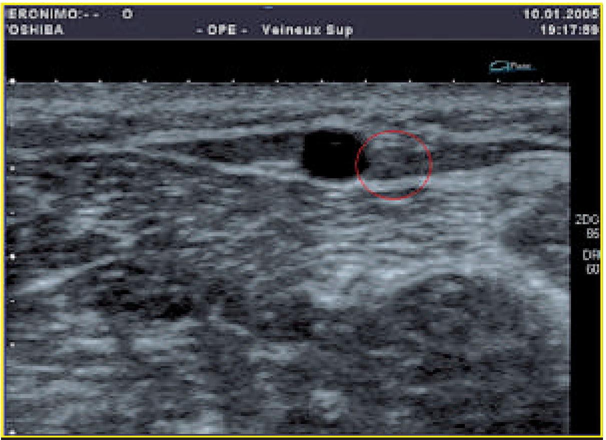


Fig. 37: SSV and sural nerve (in red circle) in the saphenous compartment (J.L. Gérard. Controversies Congress. January 2005).

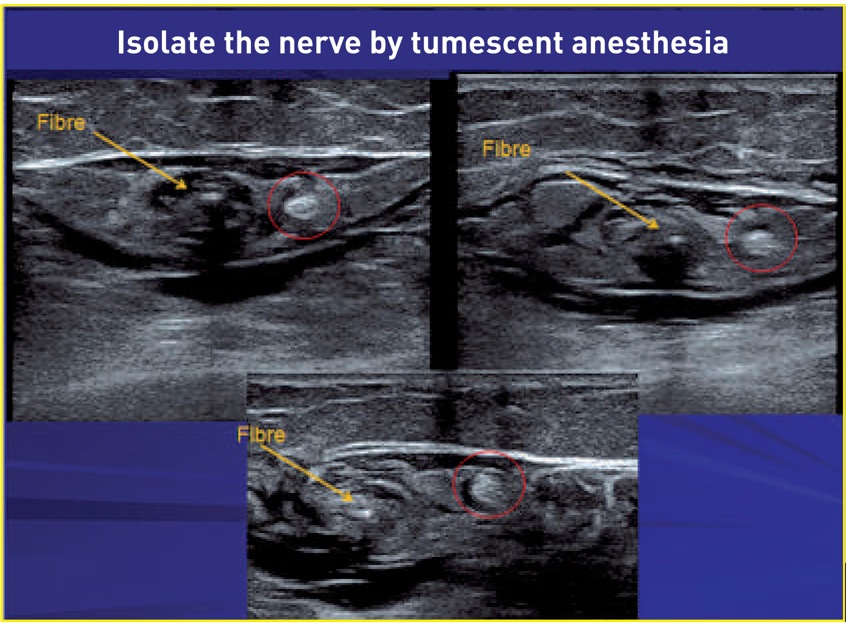


Fig. 36: During tumescent anesthesia, the nerve is isolated and pushed away from the vein.

on ultrasound with this characteristic honeycomb cross-sectional image **(Fig. 33)**.

Due to the numerous variations in SSV terminations, preoperative mapping of this vein is widely accepted, but at the same time mapping the anterior tibial nerve, fibular nerve and sural nerves should also be systematic **(Fig. 34)**.

In the treatment of SSV by endovenous laser ablation, there are 15 specific studies [26] that found a paresthesia rate between 1.6% and 11% for an average rate of 4%.

The identification of these nerves should further reduce this already very low rate.

At the popliteal fossa

When the termination is in the axis of the limb, usually just above the popliteal crease, the risk of nerve damage is low.

On the other hand, the higher the SSV termination (or a perforator) is located and lateralized, the greater the risk of nerve damage.

There is always a branch of the nerve, most often the fibular **(Fig. 35)**, which hooks and pulls the vein into a lateral position.

In this case, vein and nerve mapping is strongly recommended.

Local tumescent anaesthesia (LTA) during endovenous laser treatment allows the vein separate the nerve, or better still, by pushing away the nerve itself from the vein by means of tumescence **(Fig. 36)**.

Similarly, despite the ultrasound check, during LTA, the mapping of the nerves will prevent direct puncture and therefore nerve damage by the needle.

From the popliteal fossa to the bottom of the calf muscle, the sural nerve (most often the lateral sural nerve) may closely accompany the SSV at a variable level in the saphenous compartment of the vein **(Fig. 37)**.

Fortunately, this is rare, but mapping the nerve and isolating it during tumescence should prevent paresthesia (numbness) around the lateral malleolus.

At the ankle

The nerve is always in contact and sometimes wrapped around the vein **(Fig. 38)**.

Treatment of the distal part of the SSV should be avoided by endovenous thermal methods.

Perforating veins (perforators) or transfascial veins

The eponymous designation of perforators should also be abandoned and it is preferable to designate perforators according to their anatomical ratio, which allows for a common language (Table 2).

By perforating the deep fascia, a perforator is a communication between a superficial vein and a deep vein, the flow of superficial veins physiologically draining towards the deep network.

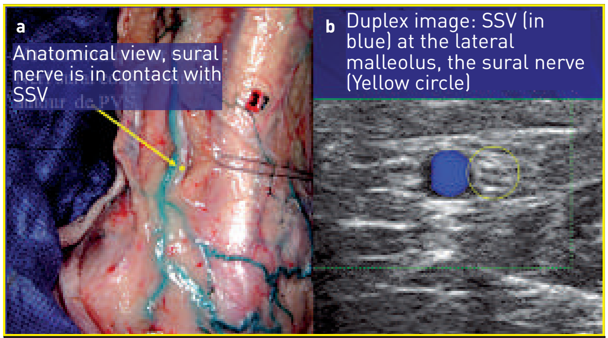


Fig. 38ab: Close relationship of the SSV and the sural nerve to the lateral malleolus.
a: anatomical view of the sural nerve (yellow arrow) and SSV.
b: ultrasound image of the SSV and the sural nerve (in yellow circle).

Table 2: Old and new terms in the Terminologia Anatomica.

DODD perforator	Femoral Canal Perforator (Hunterian)
HACH perforator	Posterolateral thigh perforator
Internal or external twin perforator	Medial or lateral gastrocnemius perforator
GILLOT's perforator	Dorsal gastrocnemius perforator
BOYD perforator	Paratibial perforator of the upper 1/3 of the leg
SHERMAN perforator	Paratibial perforator of the mid 1/3 of the leg
COCKETT perforator	Medial posterior tibial leg perforator perforator
MAY perforator	Inter-gastrocnemius perforator
BASSI perforator	Para-arachilles perforator

For some, it is distinguished only from direct or indirect perforators and in some other countries, they will define in addition centered or non-centered perforators.

These perforators are referred to as centered perforators when they drain the saphenous trunk, and as non-centered perforators when they drain a tributary or accessory vein.

Perforators can be direct when they connect the superficial veins directly with the deep veins, and indirect when they attach the superficial veins with the deep veins via muscular veins.

Perforators can be complex, multi-branched.

They may have several points of emergence at the muscle fascia and join together above it in a single trunk, or they may have a single emergence with several trunks above the muscle fascia.

A perforator can thus communicate with 2 (or more) superficial veins, or a superficial vein can communicate with 2 (or more) deep veins.

The complexity of this connection between superficial and deep veins reflects the difficulty of perforating vein surgery.

A distinction must be made between incompetent perforators and reentry (or inflow) perforators, which allow blood from an incompetent varicose vein (saphenous or non-saphenous veins) to physiologically reach the deep venous system **(Fig. 39)**.

Fig. 39: Re-entry perforators.

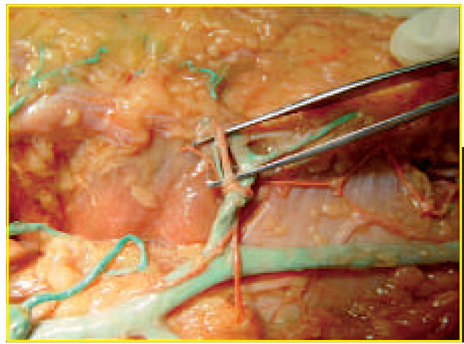


Fig. 40: Anatomical view Claude Gillot. Satellite arteries of perforators: varicose recurrence per perforator.

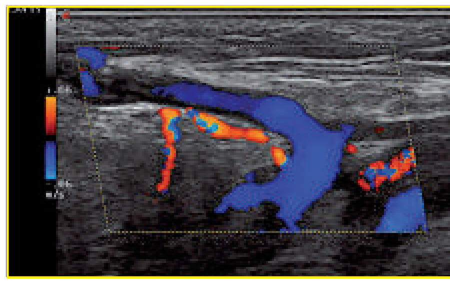


Fig. 41: Ultrasound image: the artery(s) is constant and always accompanies the perforators.

The dilatation of the incompetent saphenous vein will gradually generate an increase in the reentry flow and, as a result, the progressive dilatation of the perforator.

Although some authors have found a correlation between the diameter of the dilated perforator and its incompetence by proposing a diameter greater than 3.5 mm, competence should be analysed by studying the direction of the flow at the Duplex.

Treating these re-entry perforators would be a mistake: the ablation (surgical, chemical or thermal) of the incompetent saphenous vein reduces the number of perforators recorded before the operation.

Incompetent perforators may be isolated, sometimes after muscle trauma, after orthopaedic surgery, or appear as part of a post-thrombotic syndrome with reflux through the leg perforators.

On clinical examination, the discovery of a scar from previous orthopaedic surgery should suggest the possibility of minimal unnoticed deep vein thrombosis, and a search for an incompetent perforator that could be a source of varicose veins.

Relationship to the arteries

All perforators are always accompanied by arterioles, during the crossing of the muscle fascia, some of which are wrapped around the vein **(Figs. 40, 41)** and even beyond until immediate subcutaneous area.

As with SSV, during sclerotherapy, a color Doppler check for the absence of arterioles before each puncture must be mandatory.

You may be surprised how long these arterioles are. The same pastel pencil as the one described for the SSV will be used to delimit a puncture zone, free of arteries.

Treatment of perforators

By surgical removal:

It is more traumatic with a risk of recurrence, especially in the case of indirect or multi-pedicular perforators.

By chemical ablation:

It is ideal for small-calibre perforators, but carries several risks: risk of arterial injection, risk of deep vein thrombosis in the event of post-thrombotic syndrome or large-diameter perforators, and risk of ineffectiveness in patients on anticoagulation treatment or in the event of incompetent of very large-calibre perforators.

The injection must be made in the varicose veins, at a distance from the emergence of the perforator of the muscle fascia. The injection should never be made into the perforator itself.

By thermal ablation:

The advantages of this method are:

- **the absence of vascular problems at first in the most obese patients,**
- **less risk of infection due to ultrasound guided puncture,**
- **no contraindications in patients on anticoagulation treatment,**
- **no risk of arterial injury,**
- **less risk of deep vein thrombosis as no intravenous injection is required,**
- **and finally, greater efficiency for large diameter perforators.**

Delicate and meticulous in execution, it should however be reserved for very large calibre perforators.

We'll distinguish:

- **Incompetent centered perforators: most often of the thigh), source of incompetence of the underlying (upstream) saphenous trunk.**
- **And incompetent non-centered perforators: independent of the saphenous trunk (most often in the leg) and which may appear after varicose vein surgery.**
- **For centered perforators, the end of the fiber/catheter is positioned in the saphenous trunk, immediately underlying the perforator's endpoint, and in the same way as for a SFJ or SPJ (which are in fact the first perforators) the energy at this level is increased (most often doubling).**
- **For non-centered perforators, position the fiber/catheter in the perforator just above its emergence from the muscle fascia.**

A special case, the popliteal fossa perforator:

It can be completely isolated without incompetence of SSV

or GSV, and without any relation to varicose recurrence after surgery.

Always located 2 to 3 cm above the knee crease on the lateral aspect of the popliteal vein, most often unrelated to the SSV, and which exploration of the SSV alone does not always reveal.

When exploring the SSV, the entire popliteal fossa should also be systematically explored for a possible popliteal perforator on its lateral area, and for a possible independent perforator on its upper part, located well above the SSV termination.

According to the theory put forward by Prof. Gillot, this perforator could have originated from a compression of the popliteal vein during the crossing of the Hunter's canal (adductor canal). The narrowness of the canal in some patients may compress the vein, resulting in deep upstream venous hyperpressure.

The perforator would act as a safety valve. This theory could also explain the more frequent varicose recurrences in the popliteal fossa.

Pelvic leak points

They are systematically looked for, in case of atypical varicose veins or perineal veins, in case of symptoms of pelvic congestion, or early varicose recurrence.

Incompetence of perineal veins does not necessarily spread over the GSV trunk, sometimes to the SSV via the PASV **(Fig. 42ab)**, or only the AASV is involved, sometimes all 3 are incompetent to varying degrees.

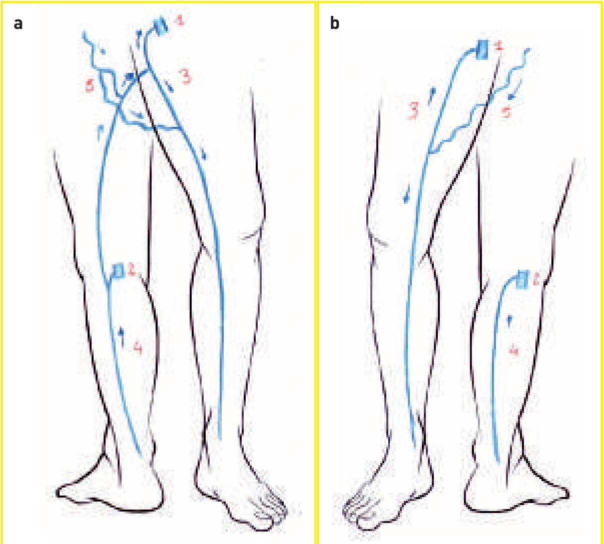


Fig. 42ab: Example of varicose veins of the thigh and leg with perineal starting point.
1. Competent saphenofemoral junction.
2. The small saphenous vein is competent.
3. The trunk of the great saphenous vein.
4. The trunk of the small saphenous vein remains competent.
5. Incompetent perineal veins transmit reflux to the suprafascial collateral of the thigh; Giacomini's vein transmits reflux from the perineal veins to the great saphenous vein.

Foam sclerotherapy can easily treat these varicose veins, which are often small in size and sinuous.

If this fails, pelvic embolization may be considered.

Vicarious veins

When a superficial vein compensates a deep vein obstruction, it is called a vicarious vein.

The superficial veins involved are essentially the GSV, by compensation in case of obstruction of the femoral (superficial) vein, but with permeability of the common femoral vein. The suprapubic veins are one of the main pathways of diversion (natural Palma) in case of iliac thrombosis and the abdominal subcutaneous veins in case of iliocaval obstruction **(Fig. 43)**.

A vicarious superficial vein, even a dilated one, is not a varicose vein. Its flow is permanent, rhythmed by the breathing and there is no reflux.

But when the deep network, previously thrombosed, recanalizes, this same superficial vein can lose its vicarious function, it can then thrombose or become varicose.

This vicariance can be confirmed by a stress test, the venous equivalent of the stress test in the arterial Duplex, which will accentuate this phenomenon.

Fig. 43: Development of flank varicose veins and abdominal subcutaneous veins during iliocaval occlusion.

Carried out in a standing position, after 10 flexion-extensions of the knees, if the GSV is vicarious, a significant spontaneous flow of physiological centripetal direction will be objectified at the level of the GSV.

Therapeutic consequence: the removal of vicarious GSV would be a mistake, as it would remove part of the deep venous return with the risk of increasing the edema of the legs.

In case of recanalization of the deep veins, GSV can be treated if it becomes incompetent, and suprapubic varicose veins, if they become symptomatic and cause real discomfort.

Varicose recurrence

After surgery, the recurrence rate at 5 years is estimated to be between 25 and 50% according to some prospective studies [26, 27, 28].

Thermal ablation, although with less follow-up (2001 to 2016), appear to show less short-term recurrency [29].

In 2000 [30], Perrin defined a new acronym REVAS (Recurrent Varices after Surgery) as the presence of clinical varicose veins on a lower limb previously treated by surgery.

In 2009 [31], the terminology of PREVAIT (PREsence of VArices after operative InTervention) extends the notion of recurrence not only after surgical treatment but also after any ablative technique (surgical, chemical or thermal).

The term PREVAIT therefore includes not only "true" recurrences (recurrent varicose veins) linked to the evolution of the disease itself, located at a distance from the operated area, but also residual varicose veins located in the area already operated on.

Often used with varicose vein recurrence, we will speak (almost exclusively in France) of unsystematized varicose veins in front of diffuse, scattered varicose veins, without direct link with saphenous incontinence and systematized varicose vein when a saphenous trunk (a part longer or shorter) source of varices remained in place.

Mechanisms of recidivism

– Residual varicose veins can be due to different causes:

- **either because of an imprecise initial diagnosis (tactical error), by ignorance of sources of perineal reflux or perforators,**
- **either by error of therapeutic strategy, the voluntary conservation of the trunk or partial ablation of the trunk of the great saphenous vein does not lead to an improvement in post-operative symptomatology,**
- **or by technical error of realization:**
  - **insufficient or incorrect initial surgery,**
  - **all sources of reflux that have not been eliminated at the junction,**
  - **incompetent perforators,**
  - **duplicate veins.**

"Modern" surgery, under ultrasound control, should limit this residual varicose veins.

– Finally, recurrent varicose veins, even after a correctly performed surgery, without any technical fault, can be due to the progression of the varicose disease.

- **Neovascularization to the previous SFJ or SPJ,**
- **Incompetent perforators,**
- **perineal varicose veins in case of multiple pregnancies after a first varicose vein treatment.**

A surgical operation without control, nor regular postoperative follow-up, leads to a varicose recurrence in the more or less long term.
This is why a phlebological scanning by echo-doppler is essential in the search for recurrent varicose veins in their early stages.
It is widely accepted, both by vascular physicians and surgeons [32], that the treatment of varicose recurrence is easily controlled by foam sclerotherapy, whether in the groin, perineal veins, perforating veins, or a tributary of the thigh or leg.
Redo surgery of the previous SFJ or SPJ is no longer necessary. Indeed, ultrasound-guided foam sclerotherapy requires no hospitalization, no anesthesia, no work stoppage, and is an easy, reliable and effective technique.

In conclusion

Duplex ultrasound investigation of the superficial veins of the lower limbs is an important part of the vascular physician's job.

This examination can only be reliable if the examiner has a good knowledge of vein anatomy and its variants, combined with good practice in ultrasound exploration of veins.

The sclerotherapy treatment is suitable regardless the location, size and depth of the varicose veins but cannot be limited only to those who are visible.

Thanks to the ultrasound-guided puncture, all varicose veins can be injected.

The treatment must start at the origin of the reflux (French method, top-down).

Thermal ablation treatments cannot be considered without the use of ultrasound.

According to the CNAM report [33], these thermal procedures should take a more prominent place in the therapeutic arsenal: "These new techniques would nevertheless allow for lighter interventions, facilitating access to care in safe environments outside the operating theater and reducing the risks of recurrence compared to the surgical "stripping" method with general anaesthesia. They finally allow a faster recovery and return to work".

Finally, in order for the patient to give truly informed consent, the vascular physician must provide information that is as complete and objective as possible.

Therefore, in order to propose the most appropriate treatment, the therapist should be familiar with the different possible techniques and use at least one or more of these other techniques.

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