Open surgery and endovenous procedure in the treatment of varicose veins

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Introduction

Over the last 20 years, varicose vein surgery has greatly evolved mainly thanks to preoperative echo-Doppler explorations. A better understanding of hemodynamic perturbations has enabled us to reduce exeresis extent while obtaining the same results and therefore to improve surgery benefit. Venous reflux that causes or enables to detect varicose disease, is a reflux between the deep and the superficial venous system. This venous reflux can be downward (pathological) or upward (functional). Taking into account these perturbations, varicose vein surgery is based on several principles:

- to remove varicose veins
- to suppress downward reflux (often located at the sapheno-femoral or sapheno-popliteal junction or at perforators)
- to suppress main or accessory trunks that let reflux flows towards varicose veins
- to keep upward reflux sources (often located at popliteal fossa level or at thigh perforator)
- to preserve trunks that present with upward flux or reflux or with well drained trunks in re-entry perforators
- to restore valvular continence

Surgery is either open surgery or endovascular surgery. Open surgery means that pathological venous elements are removed by transcutaneous way. Endovascular surgery means that pathological elements are suppressed and destroyed thanks to obliteration.The aim is similar. Nowadays every surgical procedure can be carried out on out-patients under tumescent local anesthesia without sedation.

Varicose vein removal technique

One has to keep in mind that the main purpose of any varicose vein surgery is to remove varicose veins.

Phlebectomies, such as described by Robert Muller, are still systematically performed. Thanks to a (N°11 feather) surgical blade tip or an intramuscular 18 Gauge needle, small incisions are made longitudinally. Varicose veins are removed with hooks of different sizes, curves or tips. Postoperative circular compression enables to keep the wound edges perfectly secured. Phlebectomy is very useful since it can be performed in any circumstances and enables to remove every pathological superficial vein (small veins or bulky varicose veins). Some areas without any elastic fibers are more difficult to treat (perineal, pretibial or pre-rotular veins). Thus, though very difficult to perform, sub-facial saphenous trunk removal is possible thanks to phlebectomy for example in case of a rupture of invagination stripping. A particular advantage of phlebectomies is to be painless and to give very good cosmetic results.

Varicose veins as well as insufficient saphenous vein tributary removal often enables to reduce proximal saphenous trunk diameter[1] and to suppress reflux on this proximal part of the trunk. This minimalist treatment of insufficient trunk and tributaries is called: varicose vein selective removal under local anesthesia (ASVAL).[2] This method which uses phlebectomy is part of the saphenous vein conservative surgery since it anatomically preserves the trunk and its hemodynamics function.

The CHIVA cure is a treatment using also phlebectomy. In 1988 Francheschi[3] proposed first to perform a sapheno-femoral junction (SFJ) ligation and then venous ligations thanks to a well-located phlebectomy, which enables to keep the reflux, decrease the pressure column and ensure a good reflux re-absorption in the deep venous system at re-entry perforators.

Figure 1: Peroperative view of transilluminated powered phlebectomy TriVex

More recently, a mechanical phlebectomy device has been launched on the market: the TriVex (Smith & Nephew, 160 Dascomb Road. Andover, MA 01810 USA).[4] The resector is composed of an aspirative cannula inside of which rotates a cylindrical shaped shaver. Varicose veins are resected when invaginated by aspiration through the tube. During this process, tumescent hydrodissection facilitates resection while transillumination (performed with another tube) helps clearly identify all targeted veins **(Figure 1)**. Although this technique enables to remove a lot of varicose veins, it is not very popular[5]; not only is it expensive but also very aggressive for tissues. Furthermore it generates many hematomas since it has to be performed under general anesthesia.[4]

Exeresis surgery of downward reflux

1/ The sapheno femoral junction (SFJ). Terminal valve insufficiency can be found in only 50% of the cases.[6] This insufficiency associated with the insufficiency of the femoral valve located just proximal to the SFJ is a good indication for complete resection of the SFJ (25%).[7] When the reflux has spread into the junction tributaries, these tributaries have to be resected far from the junction. Cribriformis fascia closure over the junction suture seems to be a way of limiting neo vascularization risk.[8] A terminal competent valve and an incompetent pre-terminal valve do not need a complete junction resection. A mere ligation of the saphenous vein under the collaterals while preserving their draining into the femoral vein is quite sufficient. This ligation is performed thanks to small inguinal incisions as small as a phlebectomic incision. This ligation is generally the starting point of the great saphenous vein (GSV) trunk stripping. Sometimes the anterior accessory saphenous vein (AASV) alone is incompetent. In this case, the pre- terminal valve is competent and the reflux comes from the femoral vein through an incompetent terminal valve or from the normal flux of the inter valvular tributaries. In these cases, the SFJ has to be preserved. It is sufficient to perform a mere resection of the AASV with a ligation flush to the SFJ thanks to a small inguinal incision **(Figure 2)**.

Figure 2: Resection of the AASV with a ligation flush to the SFJ

Nowadays flush high ligation, (complete crossectomie) is rarely carried out. First because terminal valve and supra saphene femoral vein are rarely simultaneously incompetent[6,7] and second because, at five-year follow up, statistically there is no significant differences between stripping with crossectomy and stripping without crossectomy.[9]

It is important to notice that, at inguinal reflux level, the main problem concerns varicose veins and varicose reservoir rather than reflux; it is not the case at popliteal fossa level.

2/ The sapheno popliteal junction (SPJ). Several series have studied results at 5 years for the sub facial ligation of the SPJ, that means a ligation far from the popliteal vein corresponding to a stripping without flush ligation. At five years, this technique gives 13.5%[10] and 31%[11, 12] recurrence rates. More recent series are worse with 50%[13] and 73%[14] of reflux recurrences at 3 months. These studies demonstrate that it is necessary to perform complete flush ligation. This complete SPJ resection is performed after carrying out a very precise echo anatomic mapping. The dissection has to be performed through a tiny incision, very close to the short saphenous vein (SSV), and with the help of a magnifying glass in order to avoid any neurological lesion; a ligation flush to the popliteal vein has to be carried out as well. Numerous SPJ anatomical variations may render this surgery difficult.

On the contrary in the multicentric Allegra study[15] bringing together 132 complete SSV resections results at 5 years show 30% of reflux recurrences. These results are equivalent to those obtained with resections without complete flush ligations. Similarly, a recent study[16] has demonstrated that the reflux recurrence percentage at one year is not significantly different between patient groups that underwent complete flush ligation and patient groups that underwent only a ligation far from the popliteal vein. This study has made it evident that with or without complete flush ligation, stripping is indeed the more important factor.

Taking into account the complex SPJ hemodynamics can also help us find answers but it especially makes us aware that a complete SPJ resection is NOT always essential.

- SSV trunk reflux can originate only from the Giacomini vein. It represents 7.1% of the cases.[17] Therefore complete SPJ resection is not required.
- When there is a common trunk between the SSV and gastrocnemius veins, the SSV trunk reflux starts below the terminal valve in 7.9% of the cases.[18] Complete SPJ resection is not required either.
- When the reflux concerns only an inter valvular tributary without any reflux in the SSV trunk, should a complete SPJ resection appear logical, it cannot be justified.
- In 6% of the cases[19-21], it is possible to find a reflux that is both systolic (at calf compression) and diastolic (at calf decompression) at the terminal valve level and that goes only upward through the Giacomini vein or through a post axial extension.

Two theories can explain this « diastolic anterograde reflux » or « paradoxical reflux »: the popliteal high blood pressure theory or the closed shunts theory. In the first theory, popliteal high blood pressure would result from a high popliteal vein compression, which is the case for about 27% of healthy adults.[22] The second theory, in accordance with the CHIVA theory[20], demonstrates that varicose tributaries are coming from the Giacomini vein and are, thanks to varicose veins, connected to perforators situated below the knee; these varicose tributaries are forming a closed shunt between the SPJ and the deep venous leg system. In this case, only an exeresis of the tributaries with a downward reflux is necessary (SPJ tributaries, SSV trunk).

It is the only hemodynamic case (diastolic upward anterograde reflux) for which the terminal valve reflux has to be respected because, in this case, the reflux represents an upward derivation towards the femoral vein. To suppress this shunt, some surgeons[20] have proposed to disconnect the Giacomini vein at the popliteal fossa level. Other surgeons[23] have suggested to suppress the incompetent part of the great saphenous vein (GSV) below the Giacomini vein connection in order to redirect the upward reflux of the Giacomini vein towards the competent proximal GSV.

For all these cases, after echographic examination, it is easy to perform, through a small incision, a mere SSV ligation below the Giacomini vein connection. This ligation can be the first step of the SSV trunk ablation.

3/ The popliteal fossa perforator (PFP). Thanks to echographic examination, the trans aponevrotic pathway of the PFP (often situated on the supra lateral quarter of the popliteal fossa) and its connection on the popliteal vein must be clearly visualized. In addition to phlebectomies, it is treated, either surgically (when easily accessible) with the same care as with the SSV, or with preoperative foam injection. In this last case, the injection is performed through a varicose vein connected to the perforator.

4/ Sural nerve vein incontinence. The sural nerve vein is a vein linked to the sural nerve and is most often situated inside the nerve and vertically laterally on the calf posterior part. This vein runs parallel and laterally to the SSV, at popliteal fossa level. It feeds the varicose veins downwards and upwards, as the SSV, it runs forwards to the popliteal fossa, first along the tibial nerve and then along the sciatic nerve. In this case, in addition to phlebectomies, this vein ablation can only be carried out by peroperative foam sclerotherapy.

5/ Thigh perforators. The thigh perforators are always «outflow» perforators. They are treated according to their size and their connection to the saphenous trunk or to the varicose veins.

a) When they are connected to the saphenous trunk, their hemodynamic function often varies as time goes by. Actually a perforator reflux cannot be pathological when it drains upwards in the trunk proximal part. Besides, the diameter of an incompetent but well-drained perforator diminishes. Incompetent perforators, which are pathological, are those presenting with a trunk insufficiency; this insufficiency can be either complete or, more often, concerns only the distal part of the trunk with regard to the perforator. Several surgical treatments have been suggested but, unfortunately, none of them have been seriously evaluated.

   - Total GSV stripping without perforator ligation can give important hematomas with recurrences risks by hematomas revascularization.
   - Distal GSV stripping with perforator ligation is a logical but difficult procedure; it is often incomplete and with recurrence risks. The vertical incision on the thigh is non cosmetic. Recurrences are often anarchic since they are not connected to a saphenous trunk.
   - Stripping or thermal ablation of the incompetent distal trunk up to the perforator with perforator drainage preservation is an hemodynamic procedure that is easier and very often enables to redirect the perforator reflux to the competent part of the remaining saphenous trunk.

b) When they are connected to varicose veins and are long and thin, as in the lateral part of the thigh, they can easily be treated by peroperative foam sclerosis; foam is injected into a varicose vein close to the perforator. But, in case of bulging and short thigh perforators, as it is often the case in the thigh medial part, only a surgical ligation has to be considered, which is quite risky. In case of large and long perforator it is possible to close the perforator with coil embolization introduced by a femoral vein approach from high downwards **(Figure 3).**[24] Endovenous thermal ablation can also be used with endovenous laser treatment (EVLT)[25-27] or radiofrequency.[28] These last two techniques are usually difficult or often inappropriate because of the tortuosity of the veins connected to the perforators.

6/ Leg perforators. They often are re-entry perforators and have to be surgically preserved. An unaesthetic cutaneous bulging should not be a surgery indication. Moreover leg varicose veins and incompetent superficial venous network

Figure 3 : Coïls embolization of a large thigh perforator

removal results in 50% of incompetent disappearance of perforators. Many authors have demonstrated that, in case of mixed treatment (incompetent superficial veins (IVS) and perforators) IVS treatment is essential and may render perforator treatment useless after incompetent superficial network exeresis.[29, 30]

The association of incompetent leg perforators, superficial and sometimes deep venous insufficiency often generates cutaneous lesions and ulcers, which put a patient in C4, C5 or even C6 class. In this case, perforator treatment is carried out simultaneously with superficial venous network treatment by sub fascial endoscopic perforator surgery (SEPS). Surgery is performed under general anesthesia with a tourniquet. Working through an incision located at the upper level of the leg medial part, the surgeon introduces an endoscope under the fascia; the sub-facial space is dissected thanks to CO_2 insufflations. Perforators are identified, dissected with endoscopic scissors and severed between two clips or coagulation point **(Figure 4)**. This is the best technique to be used when cutaneous problems do not allow transcutaneous surgery. Medium and long-term results are very satisfying especially in patients who are presenting with primary varicose veins.[31, 32]

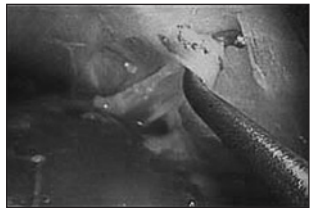

Figure 4: Sub fascial endoscopic perforator surgery

7/ Incompetent trunk ablation. GSV and SSV trunks can be suppressed either by surgical exeresis in open surgery or by endovascular thermal or chemical ablation

a) GSV or SSV stripping can be performed by using two techniques.
   The first one (exoluminal telescoping or Babcock type stripping) due to its aggressiveness on the saphenous environment should no longer be used

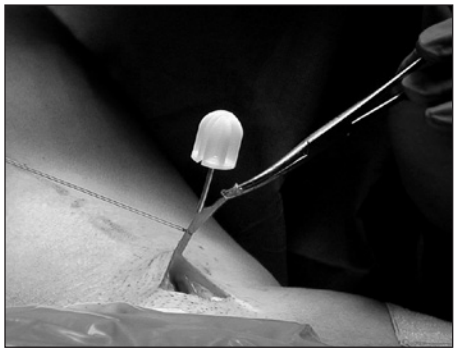

Figure 5: Exoluminal telescoping or Babcock type stripping

(Figure 5). In fact, removing the telescoped vein through the maleolar incision and then pulling out the head of the stripper with a thread through the inguinal incision is nevertheless an aggressive technique.[33]

Conversely, the second one, stripping by invagination causes very little trauma. The thread used for invagination is introduced into the saphenous trunk thanks to different devices (disposable strippers). The Pin-stripper is the easiest, most efficient device and most cost effective. It is a long re-sterilizable steel rod slightly curved at both extremities **(Figure 6)**. It is introduced from up to bottom (downwards) into the saphenous trunk. Thanks to its rigidity, it can easily be guided; after perforating the saphenous vein at the very spot where the stripping has to precisely end, the Pin-stripper is taken out through a tiny phlebectomy incision. A non extensible thread is introduced into the hole situated at one end of the Pin-stripper; this thread is attached to the saphenous vein by two knots and tied one centimeter away from the extremity. Tumescent liquid can easily be injected along the trunk as the Pin-stripper is easily perceptible with a finger. By pulling out the Pin-stripper then the thread and finally the extracted vein, invagination is performed from top to bottom. Different sizes of Pin-strippers enable to perform either very short stripping (AASV, SSV) or, with one meter-long Pin-stripper; very long stripping (complete GSV saphenectomy). The invagination drawback is trunk rupture. Should this happen, a solid experience in phlebectomy, would enable the surgeon to pull out the ruptured trunk with the taut thread

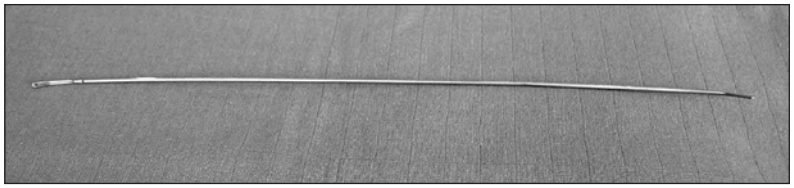

Figure 6: Pin-stripper

through a phlebectomy incision and then to resume the invagination with a new ligation on the thread.

Very few studies have demonstrated the obvious superiority of invagination over classical stripping (exoluminal telescoping). Some studies have noticed that using a Pin-stripper reduce significantly thigh hematomas[34] and greatly improve quality of life at six weeks and six months.[35] The incision size performed to take out the Pin-stripper was significantly smaller than the incision needed to take out a disposable stripper, which may also explain the improvement of quality of life.[36]

b) Nowadays, several truncular ablation techniques use thermal energy.

The Closure® catheter uses the radiofrequency, (VNUS Medical Technologies, Inc. San José, CA); it has been introduced in 1998 as ClosurePlus® catheter. The Venefit Procedure using ClosureFast™ catheter, introduced in 2007, is different: it is composed of a 7-centimeter heating anti-adhesive coated part situated at the catheter extremity as well as a handle with a cable releasing system connected to the radiofrequency generator **(Figure 7)**. The heating element consists of a spiral wire that is heated by 460 kHz alternative current and produces a 120° C temperature for a 20 second cycle. A thermocouple situated at the distal part of the heating element enables to perform a retro control on the generator action that regulates the energy in order to obtain and maintain a 120° temperature. The catheter extremity is placed below the epigastric vein ostium, about 2 cm below the terminal valve. Tumescent liquid infiltration is then performed under echographic

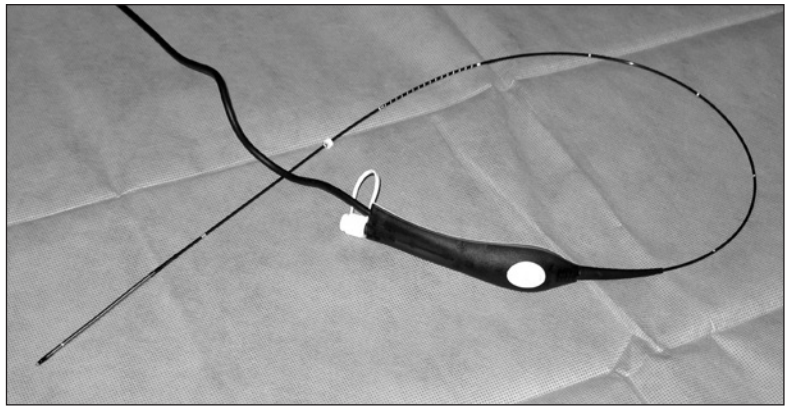

Figure 7: ClosureFast® material

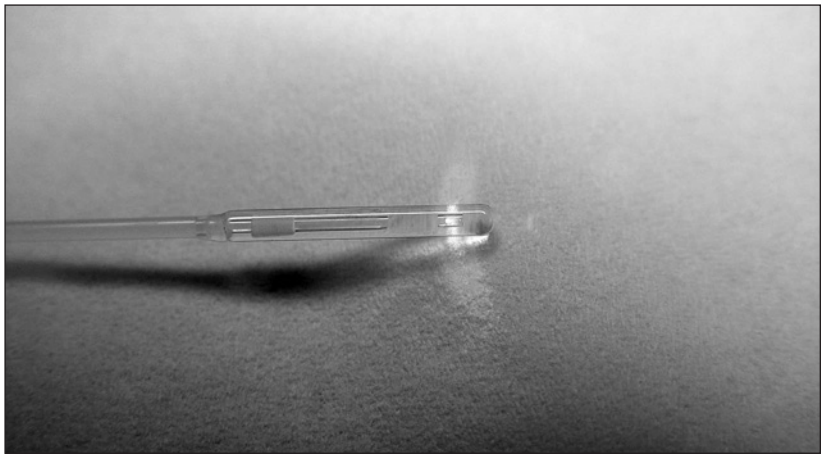

Figure 8: Radial shot laser

control. The procedure is composed of two 20-seconds therapeutic cycles at the GSV extremity and then of a single cycle for each treated vein segment. Before starting each new cycle, the catheter is withdrawn by 6.5 cm according to pre-defined marks on the catheter. Nowadays, results at five years are available for the ClosurePlus® catheter[37] and show a very small rate of morbidity with an 88% long-term obliteration rate. At present, the same studies are in progress for the ClosureFast™ catheter and they confirm small morbidity and a better 96.9% obliteration rate at 6 months[38], 97%[39] at one year and 92% at 3 year.[40] The five year results confirm the stability of the high percentage of obliterations (91.5%). It is a very easy, reliable and reproducible technique which is painless as far as post operatory effects are concerned.

Endo venous laser uses thermal action and can vary according to two different wavelength groups. The first group, the older one, uses the red and hemoglobin absorption wavelength (810-nm, 940-nm, 980-nm diode laser). In this case, light is transformed into heat by blood boiling the spraying of which transmits thermal energy to the venous wall. When coming into contact with the venous wall, the fiber extremity causes a great number of perforations that are responsible for hematomas and painful swelling syndromes occurring after surgery. The fiber extremity is placed 2 centimeters away from the saphenous terminal valve. Laser shots are performed while withdrawing the fiber. The procedure is performed either continuously or discontinuously in order to obtain a delivered energy exceeding 60 joules per centimeter long with a fluence exceeding 10 J/cm^2. This parameter depends on the trunk diameter measured after tumescence, on the power level and on the time. Studies have shown a satisfying effectiveness (93.3% obliterations at mean term), a small morbidity[41] as well as a satisfying use for SSV treatment.[42]

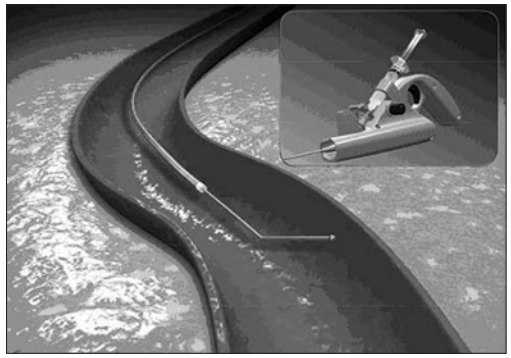

Figure 9: Mechanochemical ablation (MOCA) with ClariVein®

A more recent second group has used wave lengths that can be absorbed by water, therefore by tissues (1320-nm, 1460-nm, 1500-nm diode laser). These lasers seem to have fewer side effects (pains, perforations, swelling syndromes)[43] and, with the same level power, a better effectiveness.[44] In the future, radial shot laser should replace frontal shot laser **(Figure 8)**. These new fibers can be used without tumescence, which enables to keep watch on the shrinkage during the withdrawal of the fiber.

c) Tumescentless techniques like Clarivein™ or VenaSeal™ Sapheon Closure System are new techniques that have undergone short time research (investigations). ClariVein® **(Figure 9)** works by using a small rotating tip placed at the end of a catheter and introduced inside the leaking vein to impair the inner lining of the vein. The Clarivein system uses a chemical called "fibrovein". Several studies demonstrated that mechanochemical ablation (MOCA) appears to be safe and efficacious but based only on very short-term follow-ups.[45, 46] This technique eliminates the need for tumescent anaesthesia and is less painful than the Venefit procedure that uses the catheter ClosureFast™.[47]

As for the Sapheon glue technique, it is still at its early stage of tests. The VenaSeal™ Sapheon Closure System **(Figure 10)** uses a proprietary medical adhesive to close the saphenous vein drop by drop from high below.[48]

Figure 10: VenaSeal™ Sapheon Closure System

Flux restoration surgery

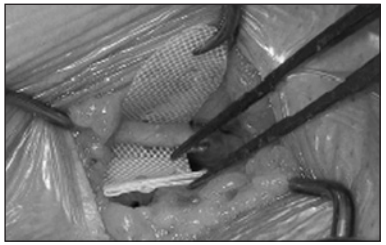

Figure 11: External valvular stenting Venocuff II®

These techniques aim at restoring saphenous trunk valvular function, and concern especially pre terminal or terminal valve. They are meant to narrow the valvular ring thanks to a peri venous circular cuff in order to restore valvular continence. Several synthetic devices have already been used and the most popular is Venocuff II® (Imthage, Sydney, New South Wales, Australia) **(Figure 11)** but, in France, it is not on the market yet.[49,50] This device is placed around the SFJ and its diameter can be adjusted like a watch band. It is fixed around the chosen valve thanks to 2 prolene sutures. Continence is checked by asking patients to perform Valsalva maneuver and leaving open a distal tributary or by performing a "milking test" maneuver. This test is performed after venous return being distally stopped by a vessel loops then blood is emptied upward and the emptied part must not be filled by reflux. This technique requires a first-rate echographic valve imaging. Pictures in B-flow mode seem to be indispensable to evaluate valvular anatomy and mobility. A controlled, multicentric prospective study[51] has showed that, after this external valvulo plasty, recurrence risk were nine times less important than after conventional surgery.

Other valvular restoring techniques with valvular transposition have been evaluated.[52] These authors have used a 2.8 mm angioscope to introduce it into a distal collateral and perform an external plicature of the valvular leaflets. After checking the valvular continence, a mid-thigh sufficient saphenous collateral was transposed into bypass on the saphenous trunk; this trunk was tied between the collateral junction and its latero terminal anastomosis situated more distally on the trunk. A total of 76 results at 5 years have shown a significant diameter decrease, an important improvement of venous function and only 9% of minor varicose vein recurrences

Anesthesia

General and spinal anaesthesia or femoral blocks are not necessary in varicose vein surgery. Apart from their being quick to perform, they only bring drawbacks to surgery. As for the first two ones, they entail peroperative vasoplegy and increase thromboembolic risks. They are not appropriate to ambulatory surgery.

The most interesting anaesthesia is tumescent local anaesthesia which provides the best per and post operative comfort. A great number of tumescent liquids have been proposed: they use Klein' solution, with lidocaïne, epinephrine and sodium bicarbonate diluted in 0.9% isotonic saline solution. In order to obtain an immediate effect, we use lidocaïne and epinephrine at 1% diluted at 0.03% in isotonic sodium bicarbonate at 1.4%. Thus, anesthesia occurs immediately after the injection. Any varicose vein surgery can be performed in this way, with a mild sedation. In about 80% of the cases, according to patients' motivation and psychological state of mind, anaesthesia can also be performed without any sedation which means that patients do not have empty stomachs (they may have breakfast) and they are able or even drive back home right after surgery. We have demonstrated that with this type of tumescent local anaesthesia without any sedation, 50% of the patients return to work the day following the operation, regardless the type of work they have.[53]

Dressing and postoperative stocking compression

Postoperative dressing is part of the surgery. It is meant to limit bleeding and reduce postoperative pain, which means that its volume and its strength have to be inversely proportional to the importance of the intervention (traumatism). Nowadays only class C5 or C6 patients need to have cotton-wool dressing with self-adhesive bandage and compressive elastic biflex-type bandage. Postoperative dressing is quickly replaced by the usual compression for C5 and C6 patients. For C2, C3 and C4 patients, who do not usually wear any therapeutic compression, a mere class II compression (20 mm Hg) is enough for one week (or two). These patients should wear two superimposed compression class II stockings for 24 to 48 postoperative hours except at night or when in decubitus position. This double compression is placed at the end of the operation thanks to stockings or panty hoses.

Ambulatory surgery

No precise rules can be applied to ambulatory varicose vein surgery. Only common sense can help find solutions. Postoperative drowsiness depends on the amount of sedation given as premedication or during surgery. Absence of premedication or Lexomil® (Bromazepam) drug type use as well as lack of sedation or short-effect Ultiva® (Remifentanil) drug type shot with an electric syringe

(0.05 Gamma/Kg/min) do not generate any postoperative drowsiness. The ideal thing would be not to use any sedation. Post operative bleeding risks can be avoided thanks to secured surgery (no electro coagulation, no extensive dissections). The main concern is postoperative pains and reduced mobility, which is why post surgery after-effects should not be painful. Tumescent local anesthesia with sodium bicarbonate at 1.4%, phlebectomy, pin-stripping, invagination or endovascular techniques, intra-dermal suture with strong and slowly resorbing stitches and efficient compression are factors that should not be missed. However vagal uneasiness risk is the only risk that cannot be avoided. That is why it is important that patients be given explanations about the usual progress of immediate post surgery after-effects (bleeding through two superimposed compression stocking during the 24 hours following surgery as well as dirty marks and tumescent liquid stains). Very precise written instructions with details about surgery after-effects should be given to patients. Postoperative effects should be comfortable enough to enable patients to enjoy a normal physical activity (two superimposed compression stocking for 48 hours then a single compression stocking for 8 days, no dressing and no stitches removal). Ambulatory surgery is successful only when surgeon and patient trust each other.

Conclusion

Scientific progress had brought us numerous new techniques, each of them with very specific purposes. Therefore it is important to have a very good command of them to choose the one that is best appropriate to the case to treat. In addition to a perfect knowledge of these techniques, the main goal is to perform a thorough comprehensive hemodynamic exploration. As little removal as possible: that is indeed the guiding principle. The general aim is varicose vein ablation and reflux ablation with reservation of the superficial venous system drainage. Provided that patients' mind condition allows it, every kind of operation can be performed on outpatients under local anaesthesia with tumescent liquid using sodium bicarbonate 1.4% and without sedation.

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