From venous pain to surgery

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Contents

HISTORY of VENOUS SURGERY

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Chapter 1

1. Introduction and review

Before discussing the history of venous surgery, we thought it would be desirable to provide you with a short semantic and etymological review to clarify or define certain terms that we will use throughout this historical review.

A. Semantic review

Etymologically the word surgery can be defined as the practice of a treatment by using one's hands. It derives from the Greek χειρουργια (kheirourgia): χειρ (kheir) [hands] and εργον (ergon) [work]. In modern language, the word surgery is used to denote any therapeutic procedure that involves one or more cutaneous incisions, or in other words, open surgery.

In this review, we will use the older definition, ie, any therapeutic intervention consisting of a manual procedure, which includes all endovascular treatments that can be performed by venipuncture. Currently, such techniques are increasingly used.

To study the chronology of venous surgery, a few other terms should be explained:

Chronic venous disease or chronic venous disorders refer to all venous diseases of the lower limbs that progress gradually and slowly; they are the opposite of acute venous disease, which is the sudden occurrence of a disorder affecting the veins. Traditionally, as we have specified, chronic venous disorders only concern the lower limbs, while the term acute venous disease can be used for all veins, whatever their location.

Varicose veins. These venous disorders most commonly affect the lower limb, commonly and inappropriately referred to as the "leg," even though anatomically, the leg is the region extending from the knee to the foot. Varicose veins of the lower limbs can be described as a visible dilatation of the superficial veins, which most often have a tortuous appearance. Their function is altered insofar as they have lost their ability to return venous blood effectively to the heart. Varicose veins are classified as a chronic venous disease.

A thrombosis is the occurrence of a blood clot in the lumen of a vein; this term should be used instead of "phlebitis," which etymologically means inflammation of a vein. The terms paraphlebitis and periphlebitis, still sometimes used, should be banned because they do not correspond to any defined venous disease.

A thrombosis is an acute venous disease; it can affect the three venous systems of the lower limb, either as an isolated event or in combination, but it is deep vein thrombosis that is the most harmful. Such thrombosis quite often produces late-onset complications, in particular when it occurs in a deep vein of the lower limb, and it is then referred to as postthrombotic syndrome. Unlike acute thrombosis, postthrombotic syndrome is a chronic venous disease because, like a varicose vein, it progresses and worsens.

B. Review of anatomy and pathology

In the lower limb, the veins are distributed into three systems.

1) *The superficial venous system (Figure 1)*, divided into two networks

- Two collecting veins, the saphenous veins: the great saphenous vein and the small saphenous vein, which are located in the superficial fascia.
- The nonsaphenous veins lie outside of the fascia. They drain blood from the superficial tissues into the saphenous veins; the term "collateral vein" should no longer be used to denote them, the most appropriate term to use is tributary vein. Therefore, there are tributary veins of the great saphenous vein and of the small saphenous vein.

The term "varicose veins" is reserved for abnormal veins in the superficial venous network.

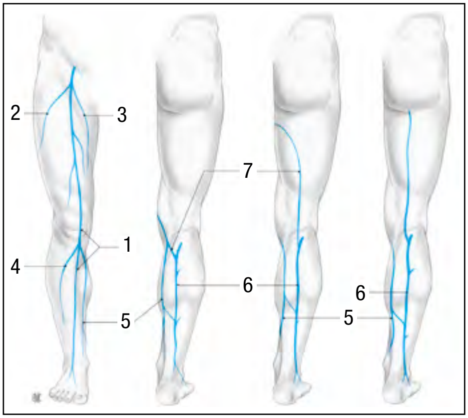

Figure 1. The superficial venous network of the lower limb
1. great saphenous vein;
2-5. tributaries of the saphenous veins;
6. small saphenous vein;
7. vein anastomosing with the great and small saphenous veins
Source: Perrin M. Affections veineuses chroniques des membres inférieurs. Généralités. Rappel anatomique et physiologique. In: Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2006:43-160.

The deep venous system

As its name suggests, this system is located in the deep tissues in the sub-fascia compartment and it drains 80% to 90% of venous blood. The two saphenous veins empty into the deep venous system. The great saphenous vein empties into the common femoral vein and its distal segment is called the saphenofemoral junction. The small saphenous vein most commonly ends in the popliteal vein and its distal segment is called the saphenopopliteal junction.

The perforating vein system

These are veins that anastomose with the deep and superficial venous systems, in addition to the saphenous junctions.

The valvular apparatus

The lower limb veins below the inguinal ligament contain valves in their lumen and along their entire length *(Figures 2A, 2B, 2C, 2D)* that allow blood flow only from the periphery to the heart. A valvular lesion can be of unknown or poorly identified cause (idiopathic), as is the case in so-called primary varicose veins or in primary deep vein insufficiency. Valvular lesions or abnormalities can either have a known cause (postthrombotic) or, in rare instances, be congenital.

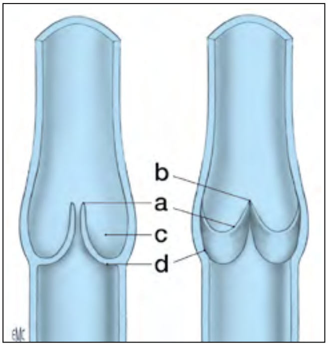

Figure 2A. Schematic diagram of a venous valve

a. Free border of valvular cusp;

b. Valvular commissure;

c. Valvular sinus;

d. Implantation of valvular cusp on wall of vein.

Source: Perrin M. Affections veineuses chroniques des membres inférieurs. Généralités. Rappel anatomique et physiologique. In: Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2006:43-160.

Figure 2B. Great saphenous vein valve: open. Doppler ultrasound appearance

The 2 open valvular cusps are identified in the venous lumen and appear as 2 vertical white lines.

Source: Perrin M. Affections veineuses chroniques des membres inférieurs. Généralités. Rappel anatomique et physiologique. In: Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2006:43-160.

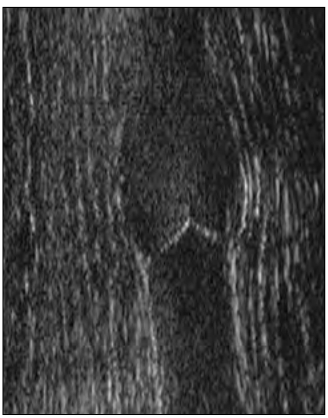

Figure 2C. Great saphenous vein valve: closed. Doppler ultrasound appearance

The 2 valvular cusps whose ends are in contact in the venous lumen resemble a circumflex.

Source: Perrin M. Affections veineuses chroniques des membres inférieurs. Généralités. Rappel anatomique et physiologique. In: Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2006:43-160.

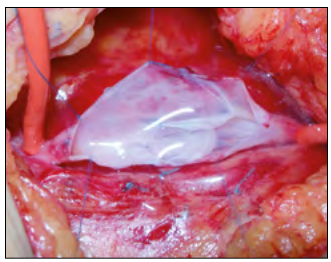

Figure 2D. Surgical view. Femoral vein valve

Courtesy; Maleti MD

C. Review of physiology

In the lower limb, blood flows from the superficial veins into the deep veins at the saphenous junctions and through the perforator veins. *(Figure 3)* The deep veins return blood to the heart via the iliac veins, and then the inferior vena cava. The latter ends in the right atrium after crossing through the abdomen and the thorax.

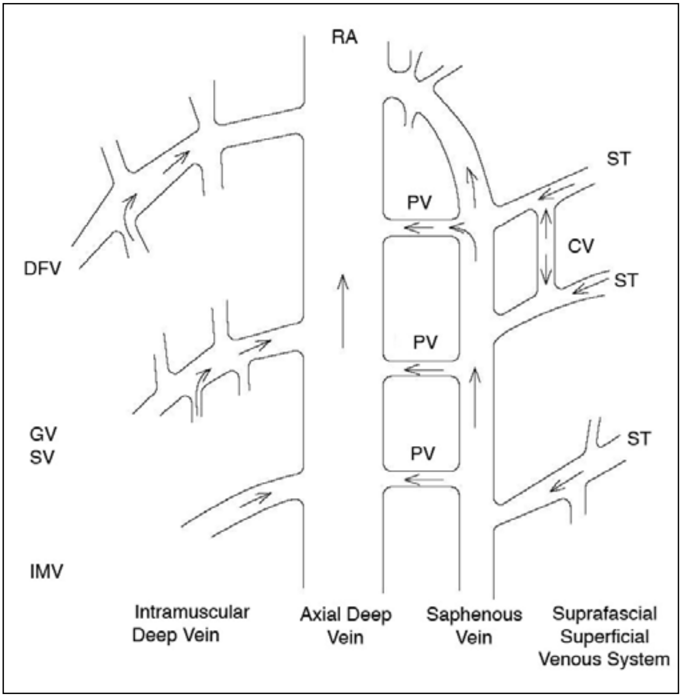

Figure 3. Emptying of lower limb veins during muscular systole

DFV: deep femoral vein
GV: gastrocnemius vein
SV: soleal vein
IMV: intramuscular vein
PV: perforating vein
CV: communicating vein
ST: saphenous tributary

2. History of venous surgery

It might seem reasonable that venous surgery only began after scientific knowledge had been acquired on the anatomy and physiology of the veins and on their pathology and pathophysiology. There is, in fact, no truth to this, but this is not specific to the veins. During each era, "specialists" were persuaded that they had knowledge, which in fact proved erroneous and unfounded as advances gradually were made in this field. In the 17th century, Molière had a premonition of this event by making fun of the practice of bleeding someone to treat any disease. It is possible, or even likely, that our current knowledge of venous disease and its treatment with surgery will be called into question in future decades. For a long time, venous surgery was limited to varicose veins.

Figure 4. The Ebers Papyrus

A. Ancient Egypt

The Ebers Papyrus (27th Pharaonic dynasty, 1580-1320 BC) clearly contraindicated surgery for varicose veins: "Instruction concerning swelling of blood vessels. If thou examine a swollen blood vessel under the skin of a limb and its aspect increases, becomes sinuous and serpentine, like something swollen with air, then thou will say concerning it, it is a swollen blood vessel—Thou shall not touch something like this" *(Figure 4)*.

B. The Greco-Roman era

Hippocrates, born in Kos (Greece), was also relatively opposed to surgery for varicose veins. At most, he recommended making punctures or tiny incisions in them once, supplemented by compression, but emphasized that the occurrence of an ulcer could be related to the incisions.

Aulus Cornelius Celsus (Rome, ca 25 BC-ca 50 AD) was probably one of the first to operate on varicose veins, but it is not known with certainty if he was a doctor. He performed avulsion of varicose veins with a hook—today this technique is called phlebectomy by mini-incision. He gave us a precise description: "Make an incision of the skin covering a varicose vein, spread apart the edge of the wound with a small hook and use a scalpel to detach the varicose vein from the surrounding parts, taking care not to injure them. After it has been detached, a small blunt hook is placed below it, always leaving a 4-finger interval between the incisions, and the same operation is continued on the vein. It is easy to ascertain its direction by the hook method. Thus, after these varicose veins have been detached, they are removed with the hook next to which they are cut: then the nearest hook is passed, with which the vein is removed in the same manner and is again cut at this place. Thus, after removing all varicose veins from the leg, the edges of the wound are brought close together by applying an agglutinating plaster."

Certainly, the current technique of phlebectomy is slightly different, but the principle is the same, it involves closer and closer excision of the varicose vein. What did definitely change is the pain experienced by the patient during this procedure. In fact, Caius Marius, the Roman tyrant who died in 86 BC, was very probably given a red wine "anesthetic" as premedication as was the custom at the time before an operation on one side. He refused to be operated on the other side and declared that the "treatment was worse than the disease". Tumescent local anesthesia, currently used in surgery for varicose veins, is as effective as it is painless.

A very complete Byzantine document was written a few centuries later by Oribasius of Pergamum (325-395?). Varicose vein surgery fills three chapters of his surgery book on this topic and some of its recommendations are still relevant:

1. Resection of veins is preferable to ligation, which can cause new varicose veins.
2. Shave and wash the limb (with hot water) before operating on it.
3. While the limb is still warm, mark the varicose veins on the skin with the patient in standing position.
4. Resect the veins of the leg before those of the thigh.
5. Remove blood clots (hematoma) by pressure on the operated limb.

Aetius of Amida (Mesopotamia 502-575?) appears to be the first to have proposed ligation of varicose veins. Paul of Egine, also a Greek (607-690?), provided a new approach by combining phlebectomy and ligation in treatment of the varicose great saphenous vein.

C. The Arabs

The most famous surgeon of his time was an Andalusian from Córdoba (930-1013?) Abu-Al-Qasim Khalaf Ibn'Abbas Al-Zahrawi, and thankfully posterity has retained only the last part of his name, who described stripping of the long saphenous vein in an exceptionally detailed manner.

D. The Middle Ages and the Renaissance

The Frenchman Guy de Chauliac (1298-1368), probably the only doctor to have treated four popes in Avignon, France, proposed a classification system of cutaneous ulcers based on their appearance (*Figures 5A, 5B, 5C, 5D*) in his four-volume treatise on surgery. He classified them as "clean and healthy, virulent and corrosive, sordid and rotten, deep and cavernous." The most common venous etiology in the lower limb would only be established much later, but the illustrious "surgeon" from Montpellier proposed treatment by cauterization of both the ulcer and the varicose veins. Ambroise Paré, a French anatomist and surgeon (1510-1590), recommended exactly the same treatment 200 years later.

Figure 5A. Venous ulcer. Above the ulcer, an area of pigmented skin and the dilated great saphenous vein are identified

Figure 5B. Medial venous ulcer at the gaiter area with a necrotic zone

Figure 5C. Large medial venous ulcer at the gaiter area

Figure 5D. Lateral venous ulcer surrounded by lipodermatosclerosis and eczematous dermatitis

E. The 17th and 18th centuries

Although the Englishman William Harvey was the first to correctly describe the physiology of the venous circulation in 1628 in a work entitled "Exercitatio Anatomica de Motu Cordis et Sanguini in Animalibus" *(Figures 6A, 6B)*, the leadership in surgery remained in continental Europe in the 17th century with the Frenchmen Pierre Dionis (1643-1718), surgeon to the Royal Family, and a contemporary of Molière and of Jean-Louis Petit (1674-1750), who was a member of the Royal Academy of Surgery under Louis XV. Both Dionis and Petit advocated surgical treatment of varicose veins with no special innovative technique, although Dionis expressed the reservation that "ligation of a vein can be cruel and painful and have unpleasant effects."

Johannes Schultheiss, a German surgeon whose Latin name was Scultetus (1595-1645), developed his own hooks to perform phlebectomy.

Figure 6A. Cover of William Harvey's book, the first to correctly describe the venous blood circulation. 1628. Frankfurt

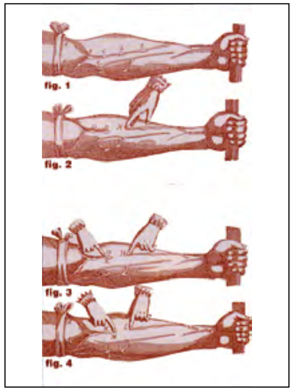

Figure 6B. The famous diagram in William Harvey's book identifying the role played by valves in the venous circulation

In the 18th century, leadership in surgery crossed the English Channel. John Hunter (1728-1793), a Scot, took up a range of topics, both in medicine and in surgery.

In vascular surgery, in particular, he is known for having performed surgical treatment on an arterial aneurysm of the popliteal artery, but he was also interested in venous disorders and described a pulmonary embolism and differentiated septic phlebitis from traumatic phlebitis.

F. The 19th century

Figure 7. Dr Pravaz shown on the left. On the right, syringe with plunger and hollow needles

The treatment of varicose veins took a new direction with the development of sclerotherapy. The term sclerotherapy refers to the injection of a sclerosing product into the lumen of a vein, which gradually results in destruction of the vein. Some will object that this method is not surgery. This is incorrect if we use the definition given in the introduction, all the more so since the precursor of this method, the Frenchman Charles Gabriel Pravaz (1791-1853), although a graduate of the elite École Polytechnique, was also a surgeon. In 1841, Pravaz designed and made a syringe out of silver, 3 cm long and 5 mm in diameter, intended for injection of ferric perchloride into an arterial aneurysm, for coagulant purposes. The plunger of the syringe descended by tightening of a screw, thus making it possible to control the quantity of substance injected. He then fitted a hollow needle on the end of this syringe *(Figure 7)*, which allowed injection of the syringe contents into the vascular lumen.

In fact, it was the surgeons of Lyon, who lived at the same time as Pravaz and in particular Joseph Pierre Pétrequin (1809-76), surgeon in chief of the Hôtel Dieu hospital, who deserve the credit for having applied this method to the treatment of varicose veins. But the occurrence of serious adverse events discredited this method. We can judge for ourselves: following 411 injections, Weinlechner in Germany reported 18 cases of localized gangrene.

Surgery involving the removal of varicose veins saw little technical change in the 19th century. In 1884, the German Otto Wilhelm Madelung proposed making an incision along the entire length of the vein to resect it, but this was not cosmetically acceptable and was responsible for an almost 1% incidence of fatal pulmonary embolism.

In 1890, the German Friedrich Trendelenburg limited his intervention to ligation of the great saphenous vein a few centimeters from its end in patients with saphenofemoral junction reflux associated with one or more incompetent terminal valves of the great saphenous vein. It is of interest to note the following:

- Such ligation of the great saphenous vein at a distance from its point of emptying into the deep vein left in place a segment of the great saphenous vein draining a large number of tributaries above an incompetent valve *(Figure 8)*. Thus, theoretically the reflux was not eliminated and it worsened or produced a dilatation and a reflux of the tributaries of the great saphenous vein since the filling reservoir represented by the trunk of the great saphenous vein was eliminated by its removal. In practice, this change was not constant.

- Moreover, Trendelenburg performed this procedure so quickly that no anesthesia was necessary…

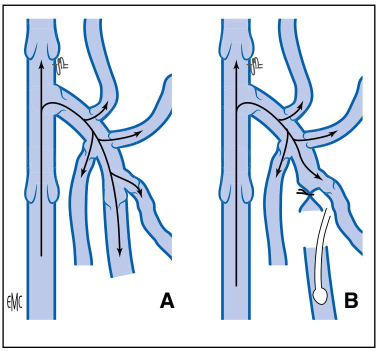

Figure 8.
A. Diagram of the saphenofemoral junction. Incompetent terminal valve of the great saphenous vein responsible for saphenofemoral reflux during the Valsalva maneuver.
B. Ligation of the end of the great saphenous vein at a distance from where it empties into the deep vein in the same patient. The stump of the arch left in place allows persistence of reflux through the incompetent terminal valve of the great saphenous vein, which will dilate the tributaries of the great saphenous vein.
Source: Perrin M. Insuffisance veineuse superficielle: notions fondamentales. In: Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2007:43-161.

In 1896 Moore, an Australian, recommended ligation of the great saphenous vein where it empties into the deep vein.

G. The 20th century

By the 20th century, venous surgery was no longer limited to treatment of varicose veins and had gradually expanded to include management of other venous diseases and treatment of veins other than superficial ones. Consequently, we will successively describe varicose vein surgery and then other procedures.

1) Varicose vein surgery

a) Varicose vein surgery without preservation of the saphenous trunk

• Open surgical excision

With the exception of the highly disfiguring Rindfleisch operation of the early 20th century (1908), modern surgery for varicose veins based on their removal began at this time. An explanation is required as a reminder of the principle on which treatment of varicose veins is based by removal without preservation of the saphenous trunk. It is based on two concepts:

- First, a general concept: open surgery was most often limited to resection or removal of diseased organs or tissues insofar as their removal did not result in an excessive mortality rate or complications and subsequently enabled patient survival under acceptable conditions. Insofar as the superficial veins are not essential to return blood to the heart, because of the decisive role of the deep veins for this purpose, their removal was possible.
- The second concept is specific to varicose veins. It was considered that the progression of varicose veins over time occurred "from the upper area downward," that is from the groin to the ankle. In other words, doctors were convinced that venous disease originated at the saphenous junction and increasingly extended toward the foot via the saphenous veins and their tributaries. Consequently, traditional open surgery consisted of ligation of the saphenous junction, and more or less extensive resection of the saphenous veins and of diseased tributaries. Since it was considered that the first incompetent valve was the last saphenous valve, ligation of the saphenous vein had to be performed on a level even with the deep vein.

What was going to change was the technique used for removal of the saphenous trunk, which we have seen had been used for hundreds of years. The venous stripping procedure for its removal was also destined to change. To perform this procedure, a venous stripper is used, and as a reminder, this instrument:

- is either inserted into the lumen of the vein — this is referred to as an endoluminal stripper,
- or is placed around the vein — this is referred to as an external stripper.

The advantage of the stripper is that it enables removal of the vein over an extensive length by means of small incisions made at the end of the vein and through which the vein is externalized and removed.

In the early 20th century, three American surgeons codified the technique for stripping of the great saphenous vein. In 1905, W. L. Keller described stripping by invagination (*Figure 9*), which was revived in 1963 by Van der Stricht under the name of wire invagination *(Figure 10)*. In 1906, C. H. Mayo reported on his technique of external stripping *(Figure 11)*. In 1903, W. Babcock popularized endoluminal stripping by using a rigid stripper, which remained in favor for several decades.

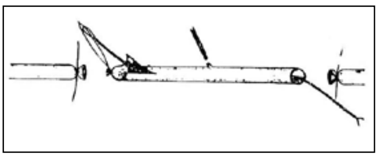

Figure 9. Venous stripping by invagination, Keller (1905)
The part of the vein resected between the 2 ligations is invaginated, as the finger of a glove, into the lumen of the vein from its upper end after attachment to a steel wire pulled through the lower orifice.

It would be too time-consuming to describe all the procedures that have marked the history of the stripping technique from the time of the flexible endoluminal stripper recommended by Myers in 1947 to pin-stripping developed by A. Oesch in 1993 *(Figure 12)*. A recently developed stripper even makes it possible to avoid having to make a lower extremity cutaneous incision.

In 1989, R. Milleret described the technique of "cryo-stripping" whose principle involves the use of a cryoprobe whose end is chilled to – 60°C-90°C with nitrous oxide.

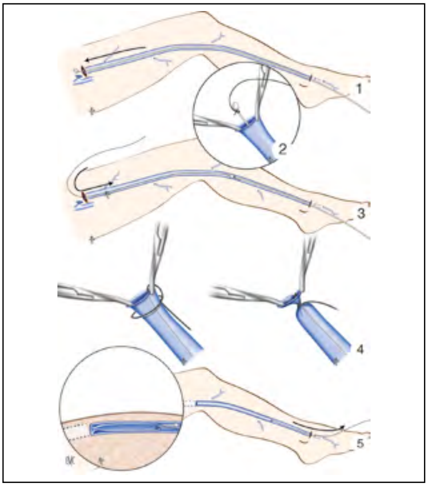

Figure 10. Venous stripping by invagination according to Van der Stricht's procedure (1963)

1. The vein is catheterized with a stripper from the distal incision to the groin.
2. A sturdy wire is attached to the stripper.
3. The stripper is pulled through the vein from groin to ankle, the wire has taken its place.
4. This wire is secured to the great saphenous vein in the groin.
5. Pulling on the distal end of the wire produces stripping of the vein by invagination.

Source: Perrin M. Insuffisance veineuse superficielle: notions fondamentales. In: Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2007:43-161.

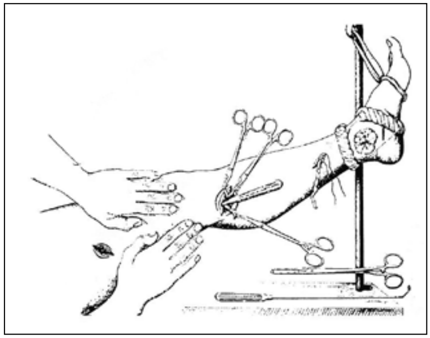

Figure 11. External stripping, Mayo (1906)

The external stripper in the right lower part of the original figure contained a ring at its end. This ring was placed around the vein like a thread in the eye of a needle while the previously sectioned vein was placed under tension by pulling on forceps and the tributary veins were successively torn away at the point of emptying into the saphenous trunk by pushing the external stripper from the skin incision below the knee up to that of the thigh. Thus, removal of the vein was achieved closer and closer to the saphenous trunk. Note elevation of the limb to minimize bleeding: the amount of blood in a vein is reduced by this position.

This probe is inserted into the lumen of the vein and the application of cold "glues" the vein to the catheter, which is removed with the cryo-stripper *(Figure 13)*.

Stripping was possibly supplemented by serial phlebectomy and ligation of the incompetent perforator veins to eliminate tributaries presenting reflux. Other teams preferred treating these abnormal tributaries and perforator veins with additional post-operative sclerotherapy.

In 1956, a Swiss dermatologist in Neuchâtel, Dr Robert Muller, gave a boost to phlebectomy by serial incisions under the term ambulatory phlebectomy. He performed this technique as an office procedure under local anesthesia and patients were immediately able to resume walking. He treated all superficial varicose veins with this method. The French and Swiss Societies of Phlebology were somewhat skeptical of this method but, since then, many dermatologists, phlebologists, and a certain number of vascular surgeons have taken up this procedure and advocate its use, albeit often limiting its indications to certain types of varicose veins.

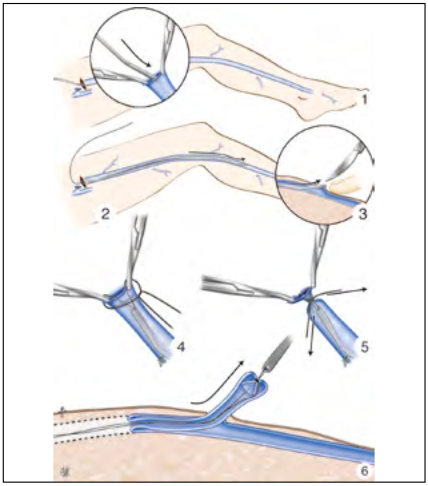

Figure 12. Pin-stripping (Oesch 1963)

1. The distal end of the pin-stripper is inserted into the venous lumen in the groin.
2,3. The pin-stripper is externalized at the lower end of the vein to be treated after making a minimal skin incision and perforation of the vein.
4,5. The wire secured to the eye hole of the pin-stripper is inserted into the venous lumen by pulling the stripper, and is then secured to the vein.
6. The stripper and the everted vein are removed through the distal incision.

Source: Perrin M. Insuffisance veineuse superficielle: notions fondamentales. In: Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2007:43-161.

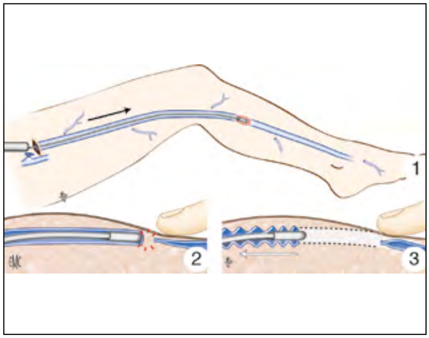

Figure 13. Cryo-stripping (Milleret 1989)

1. The cryo-stripping catheter is lowered to the lower limit of the vein to be treated.
2. After freezing, the vein is ruptured by pulling the catheter.
3. The catheter is pulled from the incision in the groin while maintaining freezing temperatures. The frozen vein is secured to the catheter. The cryo-stripper is removed through the incision in the groin. The great saphenous vein remains attached to the catheter by freezing.

Source: Perrin M. Insuffisance veineuse superficielle: notions fondamentales. In: Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2007:43-161.

• Thermal and chemical ablation

These methods differ from the previous techniques by:

- The absence of ligation of the saphenous vein junction, which eliminates the incision in the groin for the great saphenous vein or in the popliteal fossa for the small saphenous vein.
- The manner of removing the saphenous veins and their incompetent tributaries. Instead of performing excision of these veins, they are destroyed in situ.

English-speaking doctors justifiably use the word “ablation” in this definition, adding the name of the procedure used, for example “thermal ablation” or “chemical ablation.” In fact, in science, the word ablation means progressive destruction of a material (a vein, in this case) by a physical agent. Therefore, thermal or chemical ablation eliminate reflux into the treated vein after its destruction and fibrous transformation is obtained. This type of ablation differs from surgical ablation, which removes the organ treated but produces the same result in pathophysiological terms.

Figure 14A. Laser ablation method

The end of the laser catheter can be readily identified under the skin as it advances in the venous lumen.

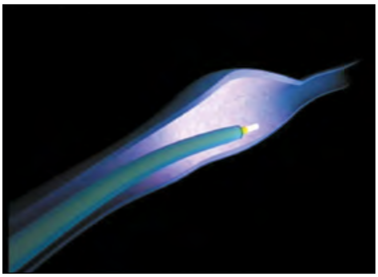

Figure 14B. Diagram

The laser catheter in the venous lumen is progressively removed downward.

Source: Perrin M. Insuffisance veineuse superficielle: notions fondamentales. In: Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2007:43-161.

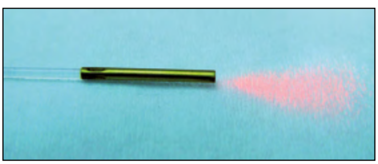

Figure 14C. Protected frontal emission laser fiber

We see the laser light in the axis of the fiber whose end is capped on the side.

It should be noted that these procedures are usually performed by venipuncture of the venous lumen identified perioperatively by ultrasound methods of investigation commonly referred to as Doppler examination, named after the Austrian physicist and mathematician Johann Christian Doppler, who in 1842 demonstrated the shift in the frequency of an acoustic or electromagnetic wave between the measurement at emission and measurement at reception when the distance between the transmitter and the receiver vary over time. In fact, the Doppler ultrasound used in phlebology couples an ultrasound device with a Doppler transducer.

As a brief reminder, ultrasound was first used during the Second World War to detect underwater submarines. In 1960, two Japanese scientists, S. Samotura and Z. Kaneko, were the first to apply ultrasound to investigate blood vessels, because blood contains formed elements, the blood cells, which are transported in the circulation in blood vessels, just as submarines travel underwater in the ocean.

Thermal ablation, laser ablation, radiofrequency ablation, and steam ablation

These methods have in common the fact that they use a catheter or a fiber that is inserted into the lumen of the vein. The tip of this catheter is heated to a high temperature and applied to the inner wall of the vein, the intima, and the heat is transmitted to the entire wall of the vein. This high temperature destroys the lumen by progressive retraction of the tissues of the wall.

- Laser ablation

A laser generator emits monochromatic light, which is transmitted to the tip of the fiber. This light energy is converted into heat energy. Without going into technical details, diode and YAG laser fibers are used, whose wavelength and type vary. A laser shot can be performed continuously or discontinuously *(Figures 14A, 14B, 14C)*.

- Radiofrequency ablation

This uses the heat properties of an electrical current produced by a generator, which is delivered at the tip of a catheter. A certain number of physical parameters can be measured continuously and precisely on the energy delivered by the catheter *(Figure 15)*.

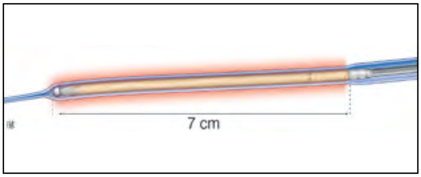

Figure 15. Radiofrequency ablation

Closure FAST™ Catheter. The circular heating element of the catheter measures 7 cm in length, which makes it possible to treat an equivalent length of vein in a few seconds.

Source: Perrin M. Insuffisance veineuse superficielle: notions fondamentales. In: Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2007:43-161.

Figure 16. Preparation of foam for sclerosing injection

Two-syringe method according to Tessari's technique.

Courtesy Tessari MD.

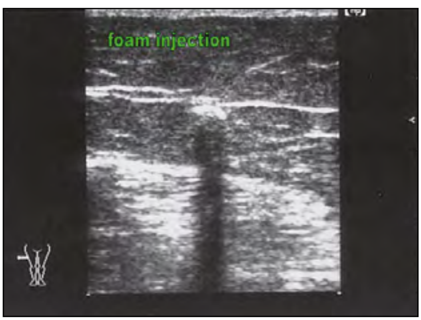

Figure 17. Doppler ultrasound during injection of sclerosing foam

The needle and the foam can readily be identified.

Courtesy Tessari MD.

- Thermal ablation by high-temperature steam

Initiated by the Frenchman R. Milleret in 2008, this is based on injection of pulsed steam into the lumen of the vein to be treated, using an electrically heated catheter. The steam condenses at the end of the catheter, transmitting heat to the wall of the vein.

- Chemical ablation

This is commonly called sclerotherapy and, like the laser method, uses radiofrequency and steam, with the advantage of safety and accuracy of Doppler ultrasound. But the novel item in sclerotherapy is the use of a sclerosing product as a foam (gas bubbles + sclerosing liquid) instead of the liquid form. This foam must be prepared just before it is to be used because it is unstable *(Figure 16)*. Venipuncture and dissemination of the foam are done using ultrasound guidance *(Figure 17)*.

Although use of foam sclerotherapy can be identified as early as 1930, it did not really develop until the last 15 years or so. The advantages of this technique have now been well identified and the protocol it uses is well-defined.

b) Varicose vein surgery with preservation of the saphenous trunk

These are open surgical procedures that use different methods but leave the saphenous trunk in place. Some of them have been abandoned, such as isolated resection over a few centimeters of the ending of the great saphenous vein or of the small saphenous vein, in which ligation of the great saphenous vein was supplemented by ligation of the perforator veins. This procedure was called crossectomy* and was proposed and performed in the 1980s by a team in Sweden.

** Crossectomy (extended saphenofemoral or saphenopopliteal junction ligation). The origin of this term, a procedure widely used in Germany, Spain, and France, is related to the morphology of the terminal part of the saphenous veins which is curved like the curved part of a bishop's miter.*

Currently, three procedures with preservation of the saphenous trunk are performed *(Figure 18)*. The rationale for these techniques is based on two points: the first is the potential utility of preserving the saphenous trunks, which are the best graft material for the replacement of diseased arteries. The second point is that the saphenous trunks promote the drainage of venous blood in the superficial tissues of the lower limb, even if in some cases they are the site of partial reflux due to incompetent venous valves.

These three procedures differ in terms of both their technical execution and their hemodynamic objective, keeping in mind that they only require very small cutaneous incisions but call for more specific preoperative Doppler ultrasound examination than the other surgical techniques.

- Phlebectomy of tributary veins

For over a hundred years it was considered that progression of varicose vein disease occurred "from the upper area downwards," as underlined above. But the systematic use of Doppler ultrasound and then of color duplex scanning to assess varicose veins called this notion into question:

- Venous reflux can be segmented, that is, highly localized to whatever venous segment;

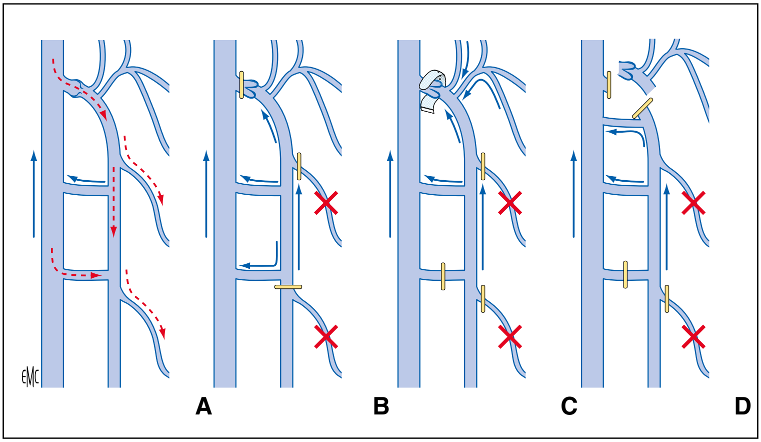

Figure 18. Varicose vein surgery with preservation of the saphenous trunk
A. Diagram of an incompetent saphenous vein. On the left: deep vein axis. On the right: axis of the saphenous vein and its tributaries. Between the 2 systems: the perforating veins. The blue or white arrows indicate the normal direction of blood flow, the red arrows show reflux.
B. ASVAL method (Ambulatory Selective Vein Ablation under Local anesthesia). The incompetent saphenous trunk is left in place. Only the incompetent tributaries are treated by phlebectomy.
C. CHIVA procedure (Conservative ambulatory HemodynamIc management of VAricose veins). The incompetent saphenofemoral junction is tied off, the incompetent tributaries are treated by phlebectomy and the saphenous trunk is tied off below reentry of the perforating vein which returns blood to the deep venous trunk.
D. The incompetent saphenous vein is left in place. A sleeve is placed on the incompetent saphenofemoral junction; reduction of the diameter of the vein restores the antireflux function of the terminal valve of the saphenous vein. The incompetent perforating veins are tied off and the incompetent tributaries are treated by phlebectomy.
Source: Perrin M. Insuffisance veineuse superficielle: notions fondamentales. In: Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2007:43-161.

- Chronologically, reflux does not necessarily develop from the root of the limb toward its distal extremity. In other words, saphenous reflux does not always begin at the saphenous vein junction. It can start in the tributary veins of the saphenous trunk.

This origin of reflux was demonstrated by N. Labropoulos (USA) in 1997 and has been confirmed by many studies.

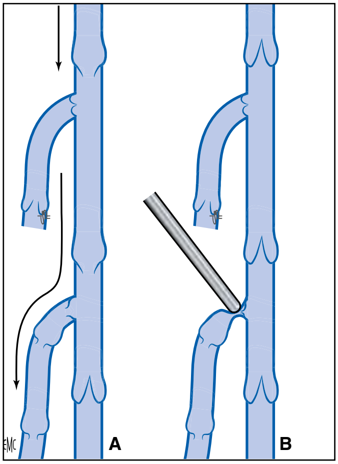

Figure 19. Decrease in capacity of the reservoir to reduce or eliminate the reflux
A. The reflux in the primary venous trunk is drained into a tributary vein whose valves are incompetent. This increases the degree of reflux into the primary trunk.
B. Compression of the tributary at its point of emptying into the primary venous trunk eliminates the reflux into it.
Source: Perrin M. Insuffisance veineuse superficielle: notions fondamentales. In: Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2007:43-161.

Lastly, the degree of reflux and probably its progressive extension are promoted by the capacity of the reservoir in which this reflux can be evacuated. Compression of an incompetent tributary vein at its mouth, into which an incompetent saphenous trunk empties, partially or totally eliminates reflux in it *(Figure 19)*. This process was mentioned in 1993 by French phlebologists.

In 1995, based on these findings P. Pittaluga (Nice, France) proposed tributary vein phlebectomy to restore valvular competence to the great saphenous vein trunk, using the acronym ASVAL (Ambulatory Selective Vein Ablation under Local anesthesia) *(Figure 18B)*.

The CHIVA procedure (Conservative ambulatory HemodynamIc management of VAricose veins)

Proposed in 1988 by Franceschi (France), CHIVA is designed to create new hemodynamic conditions by dividing the pressure column in the varicose veins by disconnecting some venous anastomoses and by redirecting the reflux from the diseased superficial veins into the deep venous system *(Figure 18C)*.

- Valvular reconstruction

The terminal valves of the great saphenous vein can be treated by such reconstruction. The principle consists in restoring valvular competence by using different procedures to eliminate reflux through these valves: valvular repair (L. Corcos, Italy, 1997), and exo-stent repair of the junction to reduce the diameter of the vein (S. Camilli, Italy, 2002; J. R. Lane, Australia, 2002) *(Figure 18D)*. It should be noted that the therapeutic principle is based on the so-called "descending" theory of varicose vein disease as in traditional open surgery.

- Perforating vein surgery

Although incompetent perforator veins are not peculiar to chronic venous disease, it is when they are associated with varicose veins that they are treated surgically. In fact, when they are incompetent, they are responsible for reflux from the deep venous system toward the superficial venous system, which produces a constant increase in venous pressure. The latter is consistently identified in venous leg ulcers. R. Linton (USA, 1939) and then F. Cockett (United Kingdom, 1955) successively identified the role played by perforating veins

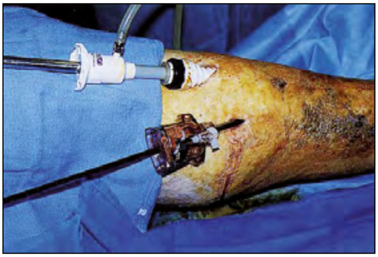

Figure 20A. Subfascial endoscopic perforator surgery

The 2 trocars are inserted via 2 minimal cutaneous incisions at a distance from the perforating vein to treat (insert). One allows introduction of a light source, the other the endoscopic surgical instruments.

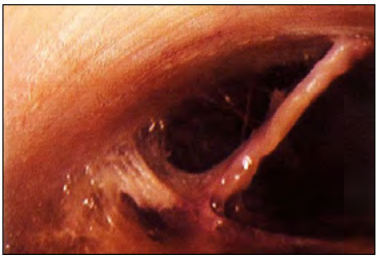

Figure 20B. The perforating vein as the surgeon sees it on the video screen

Figure 20C. Idem, after sectioning between the 2 clips

in the occurrence of venous ulcer. They described ligation of these veins by open surgery. These techniques had the disadvantage of producing delayed healing of cutaneous incisions when the skin was fragile. To compensate for this complication, Hauer (Germany, 1985) proposed endoscopic surgery on the perforating veins. This procedure gradually benefited from miniaturization of the instruments used *(Figures 20A, 20B, 20C)*.

2) Venous surgery other than varicose vein surgery

a) Treatment of deep vein thrombosis of the lower and upper limbs during the acute phase.

• Lower limbs

1. Thrombectomy

Thrombectomy is the resection of a blood clot and was the first surgical procedure performed in the treatment of acute deep vein thrombosis *(Figure 21)*. In the lower limb, this procedure is attributed to the German surgeon Läwen in 1937. In principle, thrombectomy has three objectives: prevention of pulmonary embolism, treatment of the thrombosis itself, and prevention or limiting of sequelae and postthrombotic syndrome. Combined with anticoagulant therapy, which made it possible, but also in competition with it, thrombectomy was recommended in France by Leriche, and then Fontaine, after the Second World War. It was favorably received by a few surgical teams, but did not enjoy total support by all vascular specialists. Subsequently, because of the availability of medical therapies and new techniques, the objectives of thrombectomy were called into question.

2. Fibrinolysis

In fibrinolysis, a fibrinolytic agent is administered to a patient with a thrombosis and activates plasminogen in the blood. The fibrinolytic agent converts fibrinogen into fibrin, which lyses blood clots in a process known as fibrinolysis or thrombolysis.

In 1968, the first treatment was reported in Scandinavia (Robertson). The fibrinolytic agent was delivered by intravenous infusion, which had the disadvantage of delivering the fibrinolytic agent to the thrombus in a nontargeted manner and carried the risk of bleeding.

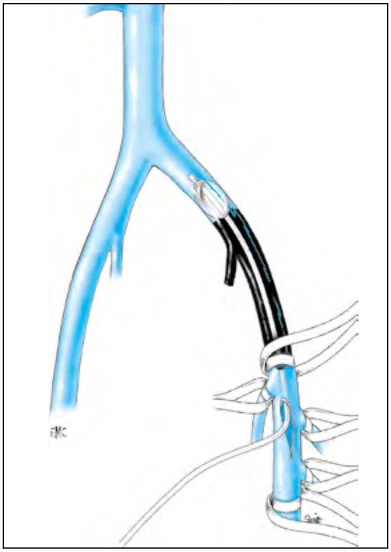

Figure 21. Thrombectomy of the iliac venous axis with a Fogarty catheter

Source: Perrin M, Nicolini P. Traitement des thromboses veineuses profondes des membres inférieurs par fibrinolyse in situ et thrombectomie. In : Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2001:43-167.

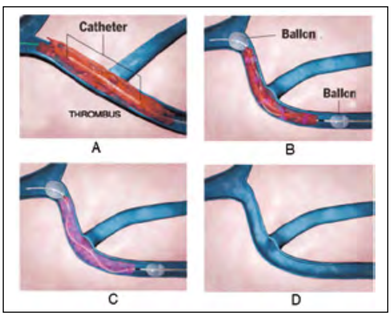

Figure 22. Mechanical thrombectomy + fibrinolysis

The catheter is inserted over a guide wire into the thrombotic deep vein. Two balloons are inflated upstream and downstream of the clot to prevent an embolism during the following phase of surgery. A fibrinolytic agent is injected between the 2 balloons while a monitor produces an oscillating movement on the central guide wire to break up the clot. The catheter and the guide wire are removed at the end of the procedure.

Fibrinolysis in situ was introduced in 1991 (Okrent, USA). Its principle consists in delivering the fibrinolytic agent with a catheter in contact with or even in the thrombus. This explains why fibrinolysis in situ is more effective with lower doses, thus decreasing the risk of bleeding.

3. Thrombectomy via an intravenous device inserted transcutaneously

The principle is to insert into the venous lumen at a distance from the thrombosis a catheter with a specific mechanism so as to break up the clot and suck it out. This mechanical action can be combined with fibrinolysis *(Figure 22)*.

4. Caval barriers

One of the major complications of a lower limb deep vein thrombosis is the migration of a blood clot from a lower limb vein into the pulmonary arteries. The result is a pulmonary embolism, of variable severity, but which can be fatal. To prevent this type of complication, the first interventions in the early 20th century involved venous ligation downstream of the thrombus, generally of the inferior vena cava. Subsequently, pericaval clips were used to divide the venous lumen into several channels (Adams - De Weese, USA, 1958). This maintained the venous circulation but prevented the migration of large emboli *(Figure 23)*.

Subsequently, clips were replaced by placement of an endovenous filter. The first such filter was based on the same therapeutic principle: it was inserted via a peripheral vein but without open surgery of the inferior vena cava, and thus was much less invasive. It was developed and used by L. Greenfield (USA) in 1972 *(Figure 24A)*. Since then, many such filters have been developed. Using ultrasound guidance they can be inserted during a bedside procedure. Lastly, insofar as the risk of a pulmonary embolism can be transient, temporary or removable filters *(Figure 24B)* have been developed.

- Upper limbs

Even though a deep vein thrombosis in the arm is much less frequent than in the leg, the first venous thrombectomy was performed on the upper limb in 1910 by Sche-

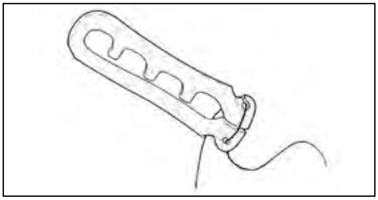

Figure 23.

Adams - De Weese filter placed around the vena cava thus segmenting the lumen, which allows passage of blood but not of large emboli.

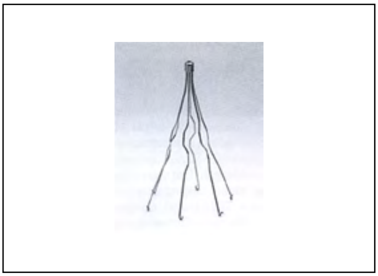

Figure 24A.

A Greenfield filter inserted percutaneously into the venous lumen at a distance from the inferior vena cava is placed in the latter to prevent passage of large emboli, resulting from a lower limb deep vein thrombosis.

Figure 24B. Venogram of an optional inferior vena cava filter

pelmann, a German surgeon. Only axillary and subclavian vein thromboses, that is, veins at the root of the upper limb, require surgery according to some authors, in particular US doctors. Just as in the lower limb, thrombolysis in situ has now replaced thrombectomy.

From the time of Paget (1866) and von Schrötter (1901), it has been known that a thrombosis of the subclavian vein can be associated with compression of vasculo-nervous structures at the junction of the thorax and the upper limb in the area between the clavicle and the first rib. Under these circumstances, an additional procedure is performed—when treatment of a venous thrombosis with thrombolysis has been chosen—removal of compression by partial resection of the clavicle (A. De Weese, USA, 1971) or removal of the first rib (Ross, USA, 1984).

b) Surgery for treatment of reflux and/or obstruction of the internal iliac and gonadal veins

It must be kept in mind that these abnormalities can be responsible for various disorders with a chronic course and for chronic venous disease, gynecological, and urinary disorders (pelvic venous insufficiency syndrome).

- Obstructive syndromes

Venous occlusion is defined as the existence of a complete blockage, and partial or total blockage of the venous lumen is referred to as obstruction. Only deep vein obstruction results in pathophysiological abnormalities, depending on its location. Generally, obstruction of a distal vein has no effect and, in particular, it is in the lower limb that obstruction of a proximal vein is harmful, in particular that of the iliac vein and the caval vein. Such obstruction may be related to a lesion of the venous lumen, most often postthrombotic syndrome, but may also be due to external compression of the vein by a tumor or an organ.

Initially, and according to the principles of arterial surgery, the bypass technique was used. The first venous bypass procedure was performed in 1948 by a Uruguayan surgeon, E. C. de Palma, who used the GSV as a vascular substitute to compensate for obstruction of the iliac vein. Subsequently, prosthetic materials have also been used.

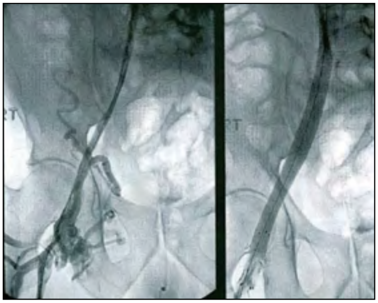

Figure 25. Treatment of postthrombotic obstruction of the iliac vein by stent placement

On the left: venography in a patient who presented with postthrombotic right iliac vein obstruction. Note the irregular appearance and narrowing of the venous lumen.

On the right: the vein has resumed its normal diameter after balloon dilatation and stent placement. Both the balloon and stent are clearly visible in the postoperative venography.

Apart from obstruction related to cancer, where it may be necessary to resect the vein and to replace it, within the last 10 years treatment with an endovenous stent has become the preferred technique. This technique involves dilatation of the stenotic area or rechanneling in the case of an occlusion, performed by inflating a balloon catheter. This catheter is inserted over a guide wire by a transcutaneous approach by venipuncture of a distant vein. Once the obstruction site has been removed or the vein rechanneled by the balloon, the stent is positioned in the lumen of the vein to prevent repeat stenosis *(Figures 25, 26A and 26B)*. This type of endoluminal surgery is less invasive than open surgery such as bypass grafting.

- Reflux syndromes

We will only discuss the deep veins, since reflux into the superficial veins corresponds to varicose veins. This reflux can involve the lower limb veins and pelvic veins.

Figure 26A. Phlebography by bifemoral catheterization with primary compression of the left iliac vein

A shunt circulation was developed by the presacral venous plexus, the left paralumbar vein and the anastomotic network of the left iliac axis into the right iliac axis.
Courtesy: J. Leal Monedero & S. Ezpeleta Zubicoa

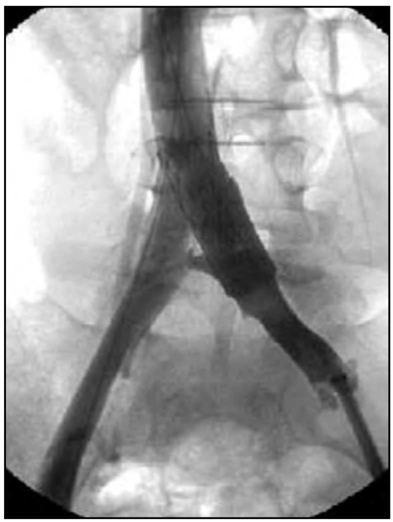

Figure 26B.

Same patient after stent placement.
Courtesy: J. Leal Monedero & S. Ezpeleta Zubicoa

1. Reflux syndromes in the lower limb

When it extends from the groin to the calf, it produces a constant, major increase in venous pressure which is especially deleterious. As in the case of an obstruction, the etiology may be primary, secondary, or congenital.

Regarding primary etiology, the valve can be identified and the procedure is called a valvuloplasty. The first such procedure was performed in 1968 by R. Kistner (Hawaii, USA), the pioneer of deep vein reflux surgery. Different valvuloplasty techniques have subsequently been proposed. In internal valvuloplasty, the vein is opened and the valve is identified under direct visual control *(Figure 27)*. In external valvuloplasty, the vein is repaired without being opened *(Figure 28)*.

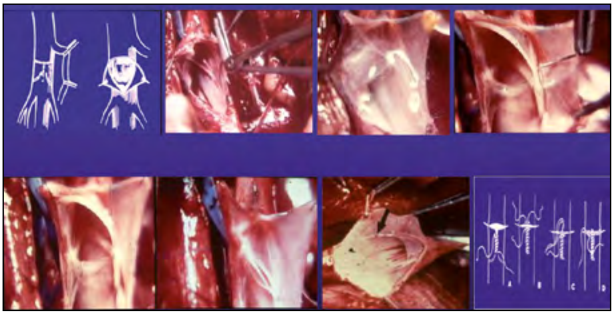

Figure 27. Internal valvuloplasty of a valve in a deep vein

From left to right and from top to bottom: Dotted line tracing and opening of the vein by a T-incision (venotomy). In the incised vein, the valve is identified and appears translucent. Valvular repair is carried out by stretching its free borders with over-and-over sutures. After the repair has been completed, the two free borders of the valves (see Figure 2C) are now in contact, and the valve is competent again. Closure of the vein with sutures.

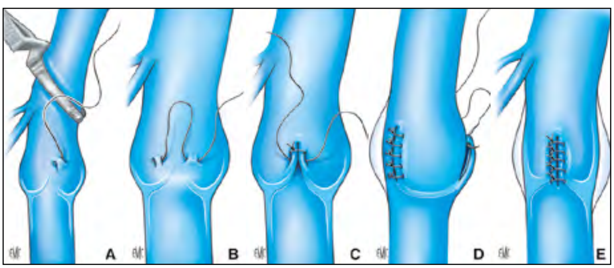

Figure 28. External valvuloplasty of a valve in a deep vein

As in internal valvuloplasty (Figures 27), the procedure consists in stretching the 2 free borders of the valves (see Figures 2). To do this, separate sutures are placed on the venous wall at the 2 commissures (see Figures 2) of the valve.

Source Maleti O, Lugli M, Perrin M. Chirurgie du reflux veineux profond. In:Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2009:43-163.

Among secondary etiologies where the cause identified is postthrombotic syndrome, the valve is destroyed by the thrombosis and cannot be repaired. Among congenital causes, the valves may be absent or atrophied, and thus the same holds true. Therefore, other surgical techniques have to be used:

- Transplantation of a venous valvular segment. In 1982, Taheri (USA) and Raju (USA) proposed using the humeral and axillary veins, which have a functional valve and can be collected undamaged and transplanted into the lower limb *(Figure 29)*.

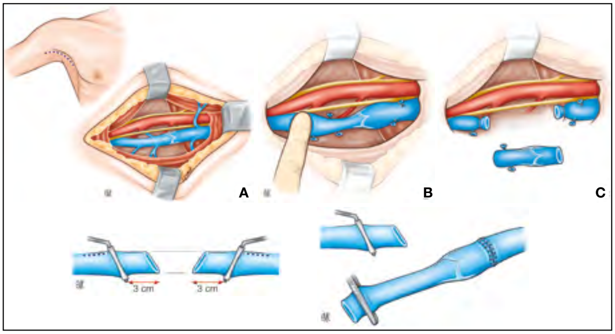

Figure 29. Transplantation of a venous valvular segment

From top to bottom
A, B, C. A segment of axillary vein is collected after verifying that it has a competent valve. An equivalent length of vein presenting reflux is resected. The venous valvular segment is transplanted. Here, only the proximal anastomosis has been performed; the distal anastomosis will restore continuity of the venous axis. Thus, a competent valve is placed in the venous axis which is the site of the reflux.

Source Maleti O, Lugli M, Perrin M. Chirurgie du reflux veineux profond. In:Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2009:43-163.

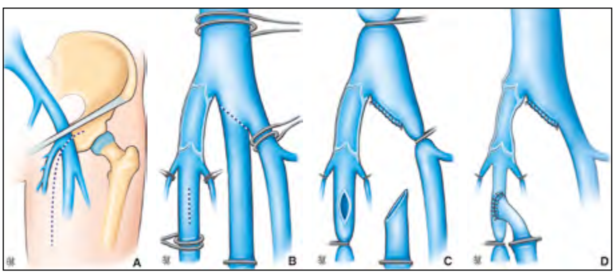

Figure 30. Transposition

The femoral vein presents reflux in the middle segment. The vein located to the left is the great saphenous vein, which has competent terminal and subterminal valves. The incompetent femoral vein is transposed below the competent valves of the great saphenous vein.

Source Maleti O, Lugli M, Perrin M. Chirurgie du reflux veineux profond. In:Techniques chirurgicales - Chirurgie vasculaire. Paris, France: EMC (Elsevier Masson SAS);2009:43-163.

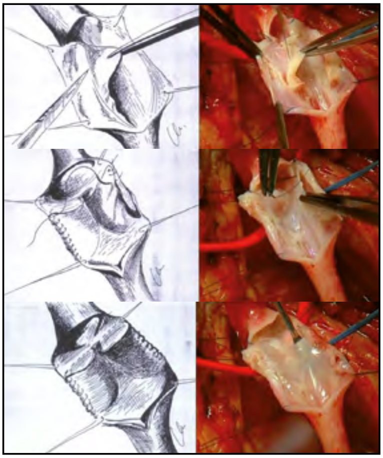

Figure 31A. Creation of a bicuspid neovalve (Maleti's technique)

From top to bottom
- After opening the vein a few centimeters along its axis, the operator divides its wall on one side into two layers.
- This detachment stopped in the middle allows construction of a sac which corresponds to a valve in a normal subject (see Figures 2).
-The same technique is performed on the other side thus creating a valve with two valvular cusps (see Figures 2).
Courtesy: O. Maleti MD

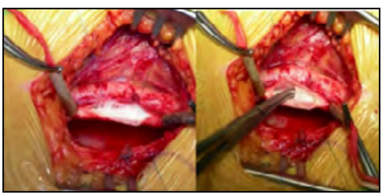

Figure 31B. Creation of a monocuspid neovalve (Maleti's technique)

- On the left. Postthrombotic thickened venous wall.
- On the right. A monocuspid valve was created by separation from the wall.
Courtesy: O. Maleti MD

- Transposition consists in transposing the vein that is the site of reflux onto another lower limb vein, below its competent valve *(Figure 30)*. R. Kistner (USA) invented this technique in 1982.

- The creation of a neovalve using venous tissue from the patient was proposed by P. Plagnol (France) in 1999 and by O. Maleti (Italy) in 2002 *(Figures 31A, 31B)*. Bio-prosthetic valves are currently being assessed.

2. Gonadal and/or pelvic vein reflux syndromes

In women, these can cause gynecological disorders such as pelvic congestion syndrome (H.Taylor, USA, 1949), vulvar or perineal varices, and lower limb varicose veins. In men, gonadal vein reflux causes dilatation of the testicular veins and can cause infertility. Such reflux can be treated with sclerotherapy, but in cases of major reflux surgical ligation of the gonadal or pelvic veins is performed. Currently, coil embolization of refluxing veins and sclerotherapy are used in combination. This procedure, proposed by R. Edwards (USA) in 1993, obliterates the veins where reflux occurs *(Figures 32A, 32B)*.

c) Surgery of venous aneurysms

A venous aneurysm is defined as an increase in the size of a vein equal to at least twice its normal diameter. It is difficult to identify the date and the author of the first surgical treatment of a venous aneurysm. A rare disorder, venous aneurysm is most often located in the popliteal vein. It is agreed that aneurysms should be treated with open surgery depending on their morphology and on whether or not there are blood clots in the aneurysm sac. After resecting the aneurysm, venous continuity is restored whenever possible *(Figures 33, 34)*.

d) *Surgery to treat the "nutcracker syndrome"*

This term refers to disease resulting from compression of the left renal vein between the aorta and the superior mesenteric artery, in a nutcracker-like configuration, which accounts for its name *(Figure 35)*. Such compression can cause lumbar pain, hematuria, and pelvic congestion syndrome by reflux of the left gonadal vein. Although surgical treatment is rarely indicated, many techniques have been proposed. First, open surgery techniques are used

Figure 32A. Selective venography of the right gonadal vein demonstrating reflux

The left gonadal vein has been embolized (with sclerosing foam + coil embolization).
Courtesy: J. Leal Monedero & S. Ezpeleta Zubicoa

Figure 32B. Same patient after bilateral embolization of the gonadal veins

Courtesy: J. Leal Monedero & S. Ezpeleta Zubicoa

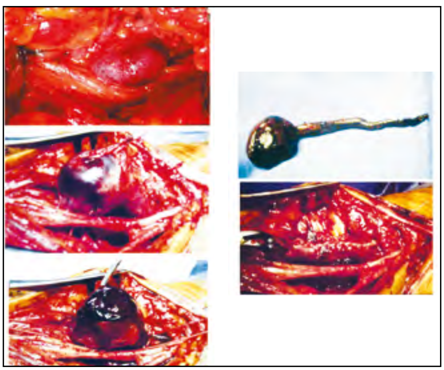

Figure 33. Open surgery of a venous aneurysm

The aneurysm contains a large thrombus. After resecting the aneurysmal sac, continuity of the venous axis is restored by closing the vein with a suture.

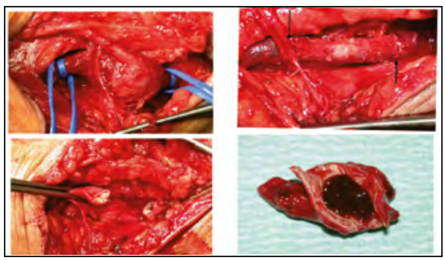

Figure 34. Open surgery of a venous aneurysm

If the aneurysm occupies the entire circumference of the vein, the operator proceeds differently, but by suturing the vein end to end, continuity of the venous axis is also restored.

Figure 35. Nutcracker syndrome

Selective venography with compression of the left renal vein with an incompetent gonadal vein.

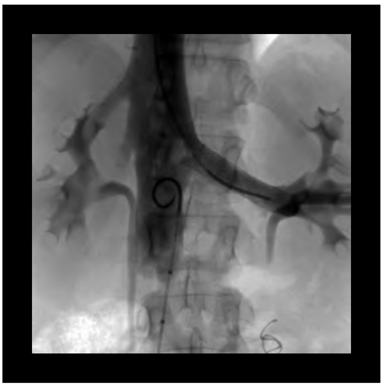

Figure 36. Nutcracker syndrome

Stenting of the left renal vein.

to eliminate compression, either by reimplanting the left renal vein or the kidney itself, or by performing a venous bypass. More recently, the nutcracker syndrome has been treated with endovenous stents (M. G. Neste, USA, 1996) *(Figure 36)*.

e) Surgery for congenital venous malformations

Severe congenital venous malformations remain the most serious challenge in phlebology. Within the last 20 years, a relatively precise consensus has been reached regarding classification, thus making it possible to divide such malformations into two groups: venous and arteriovenous malformations, with the latter being most severe. Historically, surgery, sclerotherapy, and embolization have been used separately or in combination. Pioneers associated with advances in this field include (in alphabetical order) S. Belov (Bulgaria), P. O. Burrows (USA), J. Y. Kim (Korea), B. B. Lee (Korea), D. A. Loose (Germany), E. E. Scott (USA), D. E. Szilagy (USA), J. L. Villavicencio (USA), and W. Yakes (USA). Currently, there is agreement on combined use of different surgical methods after multidisciplinary meetings.

f) Surgery for venous tumors

Primary venous tumors develop in the venous wall. They are rare and can be benign or malignant and are treated by resection of the vein with possible restoration of venous continuity depending on tumor location. Secondary tumors are an extension of an adjacent cancer or metastatic spread of cancer or a distant cancer. Surgery is used to treat them in some cases. Historically, it has been observed that surgery to remove a tumor prolongs survival following traditional vascular reconstruction procedures.

g) Surgery for venous trauma and wounds

This type of surgery has benefited from advances in intensive care and vascular reconstructive surgery, both in terms of survival as well as absence of sequelae. As a historical footnote, the French president Sadi Carnot died in Lyon in 1884 from a torn portal vein after he was stabbed in the abdomen by an immigrant anarchist, Sante Geronimo Cesario *(Figure 37)*. A. Carrel, the French surgeon who trained in Lyon and then immigrated to the USA and who later received the Nobel Prize, wrote that if at that time it had been possible to repair blood vessels, a field in which he distinguished himself, the president would have survived. In 1947, the famous Spanish matador Manuel Laureano Rodríguez Sánchez, also known as Manolete, died of an injury to the femoral vein after having been impaled by the bull “Islero” from Don Eduardo II’s cattle ranch. His name was subsequently associated with a special type of high-pass maneuver with the cape

Figure 37.

The assassination of the French President Sadi Carnot in an open horse-drawn carriage, as depicted on the front page of an illustrated supplement in "Le Petit Journal," a French daily newspaper of the time.

Figure 38.

The famous *"manoletina"* pass created by Manolete is a high-pass maneuver where the bull charges behind the bullfighter into his red "muleta."

used in bullfighting known as the "manoletina" where the bull charges behind the bullfighter into his red "muleta" *(Figure 38)*.

The Korean and Vietnam wars enabled military surgeons to better codify veins which had to be reconstructed from those which had to be ligated (N. Rich, USA).

3) Conclusions and future perspectives

It is not within the scope of this chapter on the history of venous surgery to discuss the advantages and disadvantages of the different methods, their results, and their indications, but it is the case in the last chapter of this book. Nevertheless, a few comments are warranted.

Surgery in the broader sense based on its etymological definition is increasingly less invasive, and this has transformed the quality of life of patients postoperatively.

It is likely that a certain number of venous disorders no longer require surgery insofar as their pathogenesis is better elucidated and because medical therapy will have an increasingly larger role, whether used separately or in combination with surgery.

Lastly, economic considerations will definitely have an impact on the future course of venous disease. The efficacy of treatment will have to take into account the cost-to-benefit ratio.

Before exploring varicose vein resection procedures and their postoperative treatment in depth, we will focus on pain and more specifically on venous pain. Indeed, as the link between venous disease and pain is often poorly recognized, it generates a distortion in the quality of chronic venous disease management, which leads to more severe stages of the disease, and therefore to more surgical procedures.

FROM VENOUS PAIN TO SURGERY: HOW TO DESCRIBE VENOUS PAIN?

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Chapter 2

1. Introduction

Leg pain is the commonest complaint in venous disease, and its chronic nature means that it impacts significantly on patients' quality of life.[1-4] Although frequently encountered in daily clinical practice, pain in venous disease is difficult to understand:

- *Venous pain is frequently associated with other unpleasant sensations, which are hard to describe, and which, strictly speaking, do not fall into the category of pain: feelings of heaviness, cramps, tension in the legs, pruritus.[1]*

- *The intensity of the pain is not correlated with the severity of venous disease, such that many patients suffering from venous pain have no objective clinical or paraclinical abnormalities.*

Although the physiological mechanisms underlying venous pain are now better understood and some of the biochemical and cellular processes involved have been elucidated, the causal link between venous disease and pain is hard to explain.[5,6] Everyday clinical practice shows that failure to understand generates false beliefs and prejudices regarding venous pain and its impact. This mistaken conception of venous pain is widespread in the medical world and frequently causes misunderstanding in physician-patient relations, which is likely to reduce the quality of disease management.

2. What are the general mechanisms of venous pain?

A) Anatomy of venous innervation

Veins are innervated by sensory nerve fibers in the venous wall (between endothelial cells and smooth muscle cells of the media) and in the connective tissue of the perivenous space, where they are intimately related to the microcirculation.[7,8] These subendothelial and perivascular nerve endings, which correspond mainly to small-caliber unmyelinated fibers (C-fibers), are nociceptors: they are the sole source of pain signals generated in the vein wall itself and in the perivenous connective tissue.[8] These pain signals are transmitted to the brain via the spinal cord *(Figure 1).*

B) Physiological properties of venous and perivenous nociceptors

The properties of venous nociceptors have been studied experimentally in human subjects by applying different types of stimuli (mechanical, thermal, chemical) to a vein segment while asking the subject to describe and rate the intensity of the resulting sensation.[7] It appears that these different stimuli activate the same venous nociceptors, meaning that the vast majority of nociceptors in the vein wall are polymodal. These experiments also show that when a vein is mechanically distended using a balloon catheter, pain is not felt until the diameter of the vein has tripled. In contrast to a widely held belief, vein distension, even great, is therefore not itself a significant source of pain in normal subjects. This view is lent further support by the fact that arteriovenous fistulas created surgically for hemodialysis are painless.

C) Neuromediators involved in the activation of venous and perivenous nociceptors

Studies on the mechanisms of skin pain have clearly shown that inflammatory mediators may activate nociceptors in the skin. Among the peripheral mediators involved, protons, bradykinin, serotonin, prostaglandins, and leukotrienes appear to be the most potent activators of cutaneous nociceptors.[9] Other substances such as platelet-activating factor, histamine (pruriginous at low concentration, painful at high concentration), certain interleukins, and neuropeptides also play a major role in the activation of cutaneous nociceptors. These data on cutaneous nociceptors have led to several studies of the neuromediators involved in the activation of venous and perivenous nociceptors in human subjects. Study of the painful feeling induced by its intravenous or perivenous application unambiguously shows that bradykinin is involved in the generation of venous pain.[10] In view of this response to chemical stimulation, venous nociceptors can be considered to be chemoreceptors.

The pain signals generated in the vein wall are transmitted along nerve fibers, principally C-fibers, to the spinal cord and then to the brain.

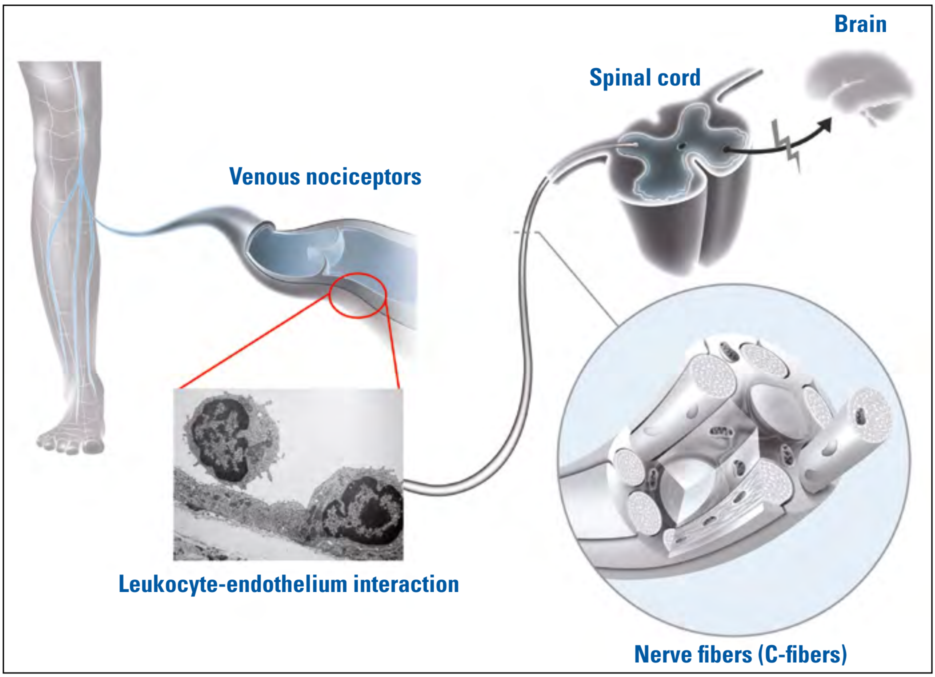


Figure 1. General mechanisms of venous pain

3. What is known about the mechanisms of pain in venous disease?

To understand the pathophysiology of pain during venous disease we need to take into account the properties of the venous and perivenous nociceptors described above, as well as the inflammatory mechanisms that characterize venous disease from its earliest stages. The likely trigger for these mechanisms is local hypoxia caused by venous stasis.[6] This hypoxia activates endothelial cells resulting in the synthesis and local release of mediators that modulate pain (activation of venous and perivenous nociceptors) and are proinflammatory.[11] These mediators include, in particular, bradykinin, prostaglandins, platelet-activating factor, and leukotriene B4.

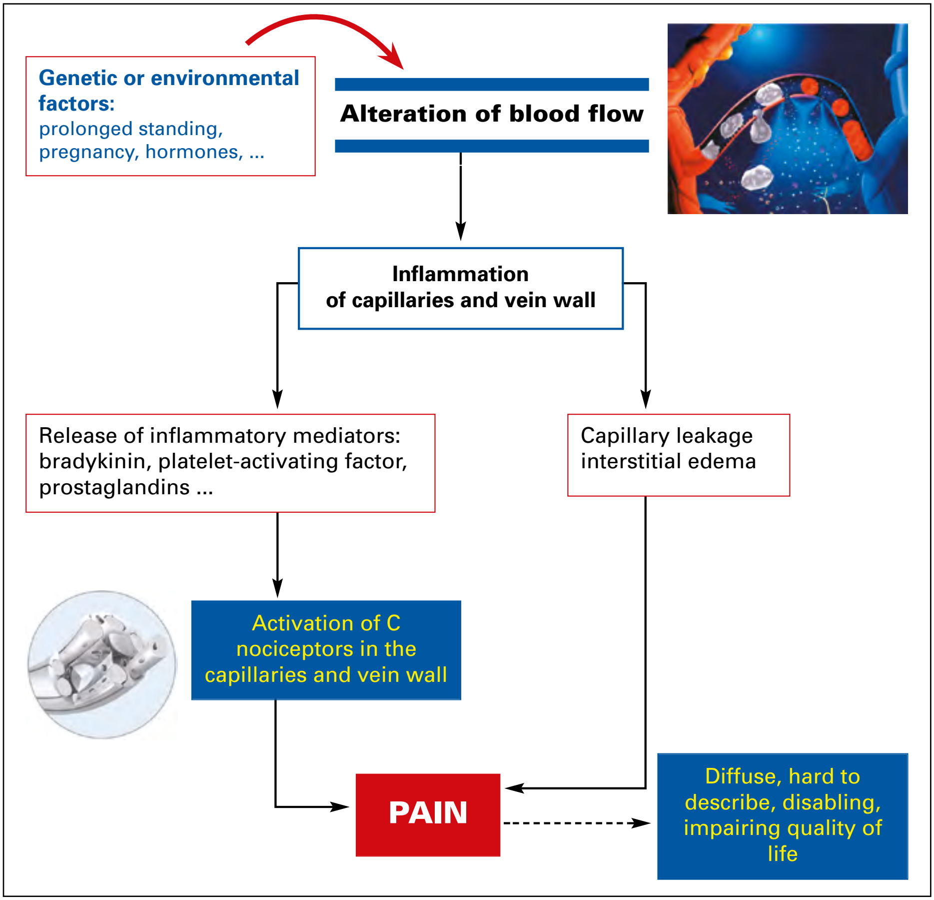


Figure 2. Venous pain is linked to nociception

Sequence of events likely to be involved in the generation of pain during venous disease.[12,13]

Evidence of such an inflammatory reaction in the varicose veins of patients has accumulated dramatically in recent years and the biochemical changes identified suggest that endothelial cells and neutrophils are the source of this local inflammation.[6,14-18]

These findings suggest that self-amplification of a cascade of reactions may lead to local release of a veritable "inflammatory soup" likely to result in activation of venous and perivenous nociceptors and in plasma extravasation with edema of the vein wall and surrounding tissue *(Figure 2).* Over time this process also leads to venous remodeling characterized by cellular and matrix alterations resulting in loss of structural integrity of the vein wall and of its elastic properties.[19] It seems then that the activation of venous and perivenous chemoreceptors by the mediators of endothelial activation and of inflammation plays a preponderant role in the pain of venous disease. This would explain the occurrence of the symptom of pain early in the course of venous disease. That's why the deeper exploration and the comprehension of the sequence of events involved in the generation of venous pain could lead to a better management of chronic venous disease patients.

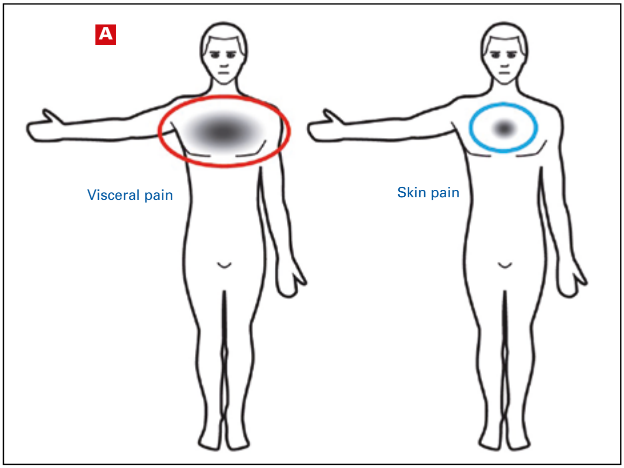
4. Why is pain not correlated with clinical severity?

Several epidemiological studies have shown that the presence and intensity of leg symptoms likely to be related to chronic venous insufficiency are not correlated with the clinical assessment of disease severity.[1] In the Edinburgh Vein Study in a population of 1500 18- to 64-year-olds, Bradbury et al showed that approximately 40% of asymptomatic patients had varicose veins on clinical examination, whereas 45% of the patients complaining of leg pain compatible with chronic venous insufficiency had no varicose veins on examination! Likewise, no significant correlation was observed between the presence of pain and the observation by Doppler ultrasound of superficial or deep venous reflux.[20]

Two remarks can be made regarding the absence of correlation between the intensity of venous pain and the extent of leg varicose veins or the severity of reflux measured by Doppler ultrasound.

First, if hypoxia is indeed the main trigger of venous pain, it is entirely conceivable that numerous painful hypoxic states occur transiently in a given patient, at the end of the day, for example, or after prolonged standing and/or certain moments of the menstrual cycle. In other words, the cascade of chemical reactions that activate venous and perivenous nociceptors may occur before any significant venous remodeling. This could explain the frequency of functional symptoms, such as pain and heaviness of the legs, in patients free of varicose veins and edema on clinical examination and of pathological reflux on Doppler ultrasound examination.

Second, the lack of a close correlation between pain and objective parameters of venous remodeling and valve incompetence suggests that venous and/or perivenous nociceptors may not be activated in the large veins but rather elsewhere, notably in the microcirculation, where there is probably a close contact between nerve endings, arterioles, veins, and capillaries.



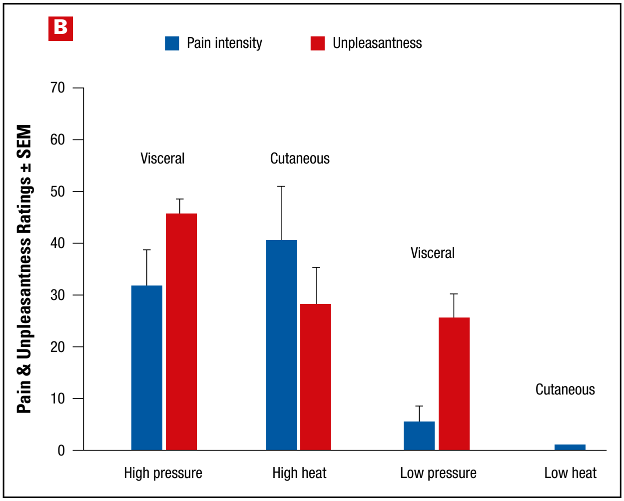


Figure 3. Visceral nociceptive messages are less localized

A. For a similar area of stimulation, the region affected by visceral pain is markedly larger than that of skin pain: visceral pain is by nature more diffuse.

B. Volunteers were asked to use a 0 to 100 point scale to rate the pain and the discomfort elicited by low-intensity stimulation and high-intensity stimulation. At low-intensity stimulation, the visceral stimulus was experienced as unpleasant, but almost painless. At high-intensity stimulation, the unpleasantness of visceral pain was well above that of skin pain, even though its intensity was lower.[21]

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5. What explains the clinical characteristics of venous pain?

Pain during venous disease is hard to interpret. Whereas the context and conditions in which pain usually occurs (prolonged standing) are generally suggestive of venous pain, several characteristics of the sensation of pain seem, at first glance, difficult to incorporate into medical/psychological reasoning:

- The pain is more or less diffuse and hard to locate;
- Patients often experience difficulty in defining the quality of the pain and frequently use vague terms that are not usually used to describe pain (discomfort, feeling of tension, heaviness, etc);
- There is an apparent mismatch in some cases between, on the one hand, relatively low pain intensity and, on the other, a strong emotional effect and a marked impact on quality of life.

These clinical features of venous pain are better understood by considering that the physiological mechanisms of nociception are similar to those of other visceral pains. As for the other viscera, and unlike skin, venous and perivenous innervation is characterized by the predominance of unmyelinated fibers and by a relatively low density of innervation. Perception of these visceral nociceptive signals, which are closely related to the autonomous nervous system, sheds light on certain clinical characteristics of venous pain. By comparison with cutaneous nociception, nociceptive signals generated in the viscera are generally harder to locate and to define. At equal pain intensity, they are often experienced as more disagreeable and have a greater emotional impact.[21,22]

The use of experimental models unambiguously shows that the discomfort induced by visceral stimulation (esophageal or rectal distension, for example) can be great even when pain intensity is low *(Figure 3)*. Apart from psychosocial factors, the management of which is obviously essential when assessing reported pain, these features peculiar to visceral pain could therefore explain in part the extent of the impact of pain on the quality of life of patients with venous disease,[3,4] even when the pain is not described as very intense.

Comparative study of experimental visceral and skin pain. Healthy volunteers were subjected to visceral stimulation (esophageal distension) and cutaneous stimulation (heat applied to the chest).

6. Why do we naturally tend to underestimate the intensity of other people's pain?

Bias in the assessment of venous pain

Over the last thirty years, numerous studies have shown that healthcare professionals generally tend to underestimate the intensity of pain experienced by patients.[23] This tendency has been recorded in extremely varied clinical settings: emergency room, postoperative care, consultation, doctor's office, specialist's office. Several interesting studies have sought to identify the main biases likely to account for this mismatch between patient-reported pain intensity and physician assessment. It turns out that the patient's pain is on average considerably more underestimated when it is chronic, when it is poorly defined or located or both, and when the underlying mechanisms are not clearly identified, particularly when there is no objective paraclinical or clinical abnormality likely to account for the reported complaint.

Everyday clinical practice suggests that various biases are particularly relevant in the setting of venous disease, because of the characteristics of venous pain and because of the lack of correlation between pain intensity and venous disease severity. The many patients who suffer pain at an early stage of venous disease, and whose clinical and Doppler findings are normal, are very likely to have their pain underestimated or even discredited or trivialized by their doctors, who, "lacking proof," often tend to consider the reported pain as exaggerated or to ascribe it wrongly to psychological factors.

It is easy to see how this widespread underestimation of pain in a clinical setting can generate a gulf of misunderstanding between patient and doctor and heighten the patient's sense of facing pain alone. Much is at stake in seeking to improve our understanding of pain in venous disease. If physicians have a theoretical understanding of the mechanisms involved in the generation of pain, they will acknowledge the patient's experience of pain, which is by its very nature difficult to explain, thereby improving the patient-physician relationship as well as pain management.

7. False beliefs about venous pain

FALSE	TRUE
In venous disease, pain is generated by vein distension caused by venous stasis.	In venous disease, pain is most probably linked to **local inflammation** generated by hypoxia caused by venous stasis.
Pain always occurs at a late stage of venous disease.	Pain can be an **early** symptom of venous disease.
Leg pain cannot be ascribed to venous disease when there are no varicose veins or when no edema is seen on clinical examination.	In venous disease, **pain can occur in the absence of any abnormality seen on clinical examination**.
Leg pain cannot be ascribed to venous disease when no reflux is seen by Doppler ultrasound.	The lack of correlation between pain symptoms and venous disease severity reflects the fact that **venous pain can occur when no reflux is seen by Doppler ultrasound**.
In a patient complaining of leg pain, the diffuse and ill-defined nature of the pain suggests that no specific organs are involved.	As it is similar to **visceral** pain, venous pain is in general **hard to locate and to describe**.
A patient who essentially complains of pain, discomfort, tension in the legs, or heavy legs is not really suffering.	As with other visceral sensations, those generated in the veins can be experienced as **unpleasant even when they are not obviously painful**, and can therefore **have an impact on the patient's quality of life**.
In a patient who reports pain, normal clinical findings and an absence of anomalous findings in complementary examinations suggest that the complaint is probably exaggerated.	In the absence of an objectively observed lesion, health care professionals have a **natural tendency to underestimate the pain** reported by their patients and to ascribe it wrongly to psychological factors.

8. Conclusion

Even though the physician can improve the management of pain, chronic venous disease is a chronic and progressive disease, and thus progresses to complications. The last chapter of this book will describe in detail the postoperative treatment after resection of varicose veins, when a surgical approach is inevitable.

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