Chapter 8

Sclerotherapy

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8

Core Messages

- Advances in the development of treatment of leg veins have resulted in the practice of sclerotherapy flourishing in the United States and abroad.
- The most common vascular disorders of the lower extremities are varicose veins, reticular veins, and telangiectatic veins.
- Hereditary factors, increased deep vein pressure, and primary or secondary valvular incompetence are the common factor involved in the development of small and large varicosities.
- Sclerosants used in sclerotherapy are available in liquid and foam preparations.

Contents

8.1 Introduction

Varicose veins and the subset of small varicosities referred to as telangiectatic and reticular veins are the most common vascular disorders of the lower extremities. Up to 60% of American adults are affected with varicose veins, and the incidence increases with age [1]. Many of these patients are affected not only by their appearance, but also by the quality of life that can accompany varicose veins. Varicosities can be associated with varying degrees of discomfort and pain, lipodermatosclerosis, venous ulcerations, thrombophlebitis, and deep vein thrombosis.

Sclerotherapy involves the introduction of a sterile foreign chemical by injection into an intracutaneous, subcutaneous, transfascial or subfascial abnormal venous lumen, resulting in transmural denaturation of the vessel wall and subsequent panvascular fibrosis and destruction of the vessel. Controversy concerning the precise mechanism of action of sclerotherapy persists. The term sclerotherapy was first introduced in 1936. However, intravascular sclerotherapy of varicose veins was initially performed in 1840, shortly after the development of the hypodermic needle, utilizing a solution of absolute alcohol [2]. Increasing sophistication in the discipline of sclerotherapy over the years has led to continued refinement of sclerotherapy techniques. Advances in the development of sclerosing solutions, prolonged post-sclerotherapy compression, accurate methods of detecting valvular incompetence and venous hypertension, and the refinement of foam sclerotherapy techniques for the closure of incompetent saphenous trunks and perforating veins have resulted in the practice of sclerotherapy flourishing in the United States and abroad.

8.2 Venous Anatomy of the Lower Extremity

An understanding of the venous system of the lower leg is important for proper treatment of varicose and telangiectatic veins. The venous systems of the leg are divided into two systems: deep and superficial. These two systems run parallel to the long axis of the leg. Ninety percent of the deoxygenated blood returning from the lower extremities is carried by the veins of the deep venous system [3]. The main function of the vessels of the superficial venous system is drainage of the venules of the skin into the deep venous system. The deep and superficial venous systems directly communicate through a series of perforating veins and also at venous junctions, where the blood of the superficial venous system drains into the deep venous system [4]. The veins of the deep venous system lie within the muscular system of the leg deep in its fascial compartment. The superficial veins course through the skin and subcutaneous tissue peripheral to the deep fascia. The perforating veins run an oblique course through the deep fascia, between muscle bundles, connecting the two systems. The mechanism of transporting venous blood from the legs is accomplished by contraction of the calf muscles (the calf-muscle pump or the peripheral heart) [2]. Therefore, the deep venous system is an important component in maintaining function of the cardiovascular system. During muscle relaxation, deep venous blood reflux in the leg is prevented by means of a passive one-way valve system (Fig. 8.1). Blood flow from the superficial to the deep venous system occurs via the perforating veins and the venous junctions during muscle relaxation when the hydrostatic pressure in the deep venous system falls below the pressure in the superficial veins (Fig. 8.1). The hydrostatic pressure in the saphenous veins of the lower extremities can be as high as 90–120 mmHg or more at the ankle when standing erect and motionless [2]. In contrast, the hydrostatic pressure at the distal aspect of the upper extremity at rest and upright is only 35 mmHg [5]. Pressure generated in the deep venous system can reach 200–300 mmHg during calf-muscle contraction, such as with walking (Fig. 8.1). Clearly, any source of prolonged increased hydrostatic pressure, such as prolonged standing or sitting in one place, will adversely affect the effectiveness of the calf-muscle pump.

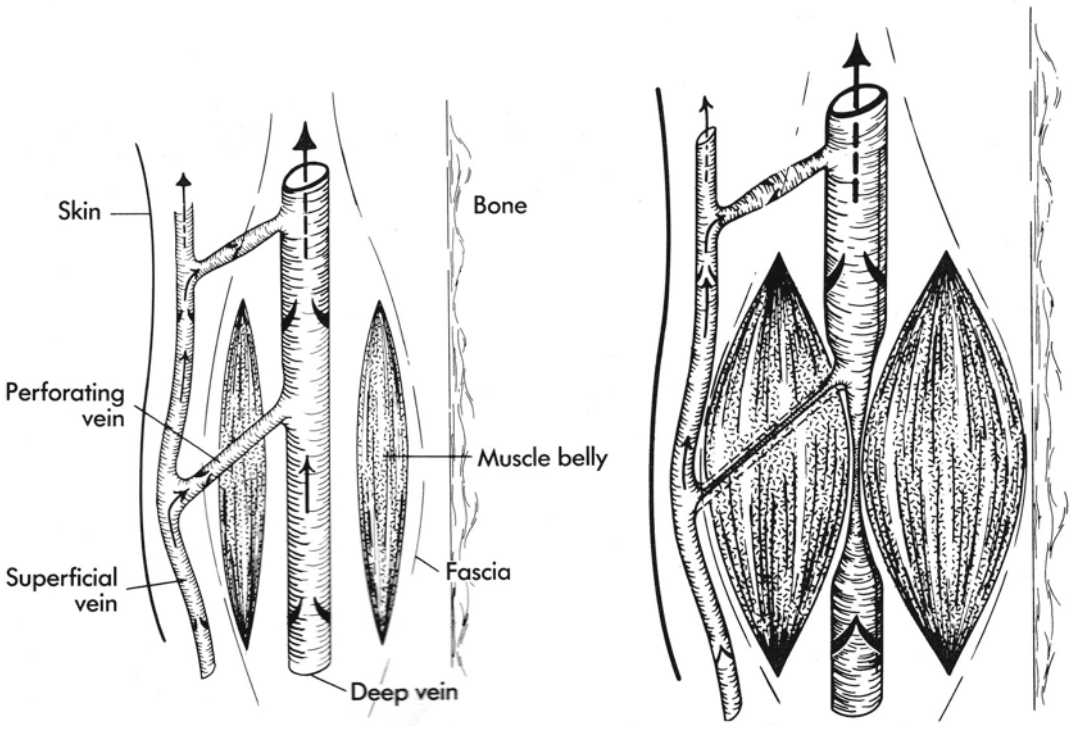


Fig. 8.1a,b. Schematic diagram of the calf-muscle pump. **a** Relaxed state: all valves are open allowing blood to flow in a proximal direction. Blood flows proximal in both the superficial vein and through the perforating vein into the deep veins. **b** With muscle contraction, the perforating veins are squeezed closed. Valves distal to the compression are closed to prevent distal blood flow. (Reprinted with permission from Goldman MP (1991) *Sclerotherapy: Treatment of varicose and telangiectatic leg veins.* Mosby, St. Louis.)

8.2.1 The Deep Venous System

The principle veins of the deep venous system of the lower extremity consist of the anterior tibial, the posterior tibial and the peroneal veins, named for their corresponding paired arteries. These veins originate in the foot as plantar digital veins. At the level of the knee, these three veins join into a single popliteal vein (Fig. 8.2). The popliteal vein becomes the femoral vein (sometimes called the superficial femoral vein) once within the thigh (Fig. 8.2). The deep femoral vein (also referred to as the profunda femoris vein) joins the superficial femoral vein of the deep venous system proximally to form the common femoral vein.

8.2.2 The Superficial Venous System

The greater (or long) saphenous vein (LSV) and the lesser (or short) saphenous vein (SSV) comprise the larger veins of the superficial venous system. These vessels are superficial to the deep fascia and muscles of the leg. The majority of cutaneous and subcutaneous veins empty into one of these two veins or their tributaries [3]. Superficial veins can also drain directly into perforating veins or anastomose with branches of the abdominal, pudendal, perineal, and gluteal venous systems, thereby bypassing the long and short saphenous systems [3]. The greater saphenous vein begins on the dorsum of the foot and ascends anteriorly and medially to join the common femoral vein of the deep venous system at the saphenofemoral junction (Fig. 8.2). The lesser saphenous vein is the most

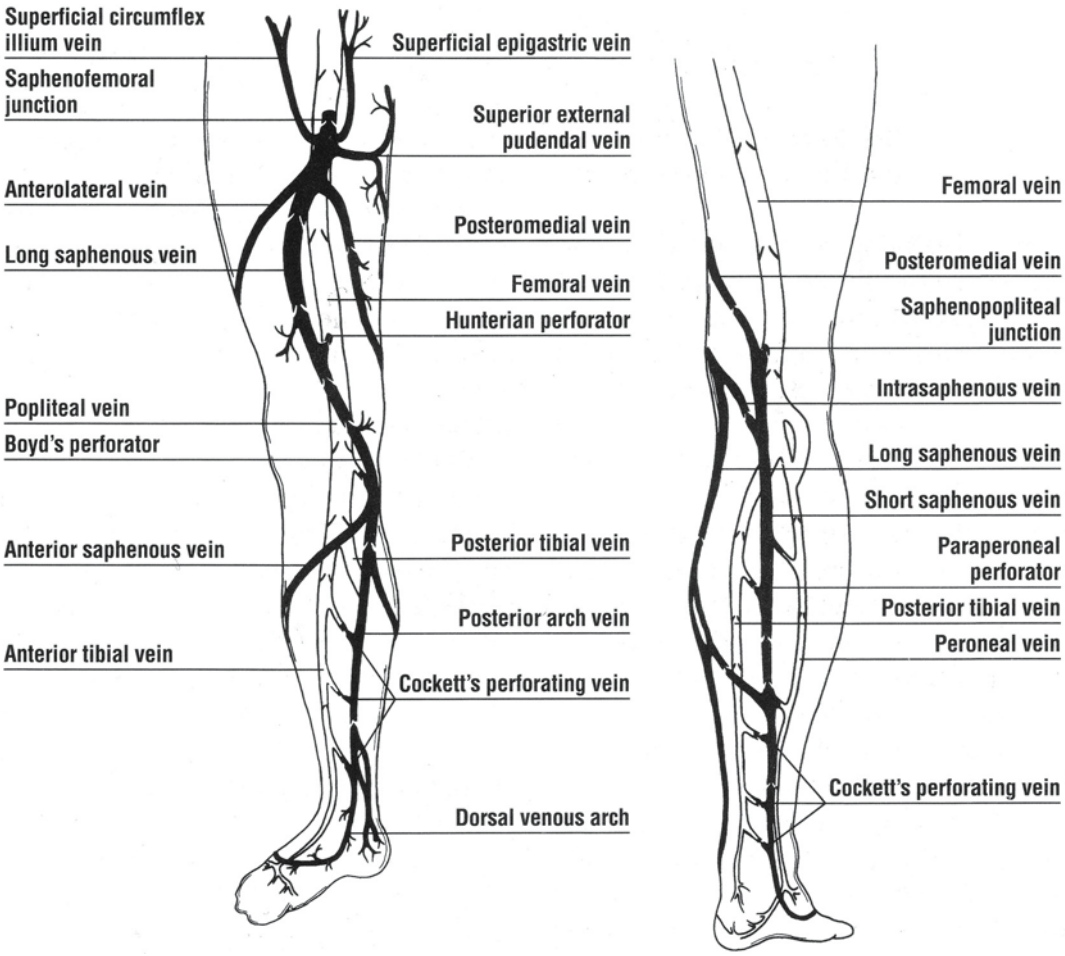


Fig. 8.2. Simplified diagram of major veins in the legs. The superficial veins are shown in solid black. (Reprinted with permission from Goldman MP (1991) *Sclerotherapy: Treatment of varicose and telangiectatic leg veins.* Mosby, St. Louis.)

prominent superficial vein below the knee and ascends from the lateral aspect of the foot and posteriorly up the calf. It terminates in the popliteal vein of the deep venous system at the saphenopopliteal junction (Fig. 8.2). Superficial veins provide a pathway for venous return from the cutaneous and subcutaneous systems. The superficial venous arrangement exhibits a marked diversity in anatomy, however.

8.2.3 Other Superficial Veins of the Leg

The accessory saphenous vein is a fairly constant vein that courses from the lateral knee to the saphenofemoral junction. Other prominent and consistent superficial veins include the anterior crural vein, which runs from the lower lateral calf to the medial knee, and the infragenicular vein, which drains the skin around the knee. The reticular or connecting branch veins may represent a normal network of blue-green-colored subcutaneous veins or when associated

with venous hypertension may be tortuous and varicose.2

8.2.4 Perforating Veins

Perforating/communicating veins connect the veins of the superficial venous system to the deep venous system by directing the one-way flow of blood into the deep venous system (Fig. 8.2). The only exception to this inward flow of blood is in the foot, where perforating veins with valves allow blood flow from the deep to the superficial veins [2]. Additionally, the majority of pedal-perforating veins usually do not contain valves. Therefore, a muscle pump in the foot must also provide a mechanism for venous return, which is activated by weight bearing. Perforating veins are present from the ankle to the groin. The number of perforating veins per leg is variable, with as few as 64 to as many as 155 per leg [2]. Most perforating veins contain one to three valves. The valvular system is unidirectional, with blood flowing from superficial veins to deep veins. This prevents the high venous pressure from muscle contractions of the deep venous system from being transmitted to the superficial veins (Fig. 8.1). The typical perforating vein is a 1- to 2-mm thin-walled vessel. When perforating veins become incompetent, the high pressure from the deep veins of the calf-muscle pump is transmitted to the superficial veins by way of the perforating veins. When incompetent, perforating veins become thick-walled and may reach a diameter of 5 mm of more. In the thigh, the Hunterian (or Dodd's) perforating veins are relatively constant and are associated with the medial intramuscular septum of the thigh (Fig. 8.2). These perforating veins connect the long saphenous vein to the femoral vein in the middle medial thigh and the lower third of the thigh. These perforating veins do not pierce muscle and consequently lose the benefit of protection from becoming incompetent by lack of support from the surrounding thigh muscles within the deep fascial compartment [3]. Hence, incompetence of the Hunterian/Dodd's perforating veins is a common cause for medial thigh varicosities in patients with a competent saphenofemoral junction. Many smaller perforating veins may also be present in the middle third of the lateral aspect of the thigh and the midline posterior thigh, connecting the long saphenous vein and its tributaries to the profunda femoris vein (deep femoral vein).

The posterior tibial perforating vein occurs in almost all limbs approximately 5–10 cm distal to the knee on the medial calf (Fig. 8.3). It connects the long saphenous vein to the posterior tibial vein. Cockett's perforating veins are comprised of a group of perforating veins located along the medial ankle coursing superiorly to the medical calf (Figs. 8.2 and 8.3). They do not drain directly into the long saphenous vein but connect the posterior arch vein of the calf to the posterior tibial vein (Figs. 8.2 and 8.3). Multiple perforating veins are also found with regularity along the medial calf. Some of these perforating veins drain into the posterior tibial vein, the gastrocnemius vein, and the soleal vein. Boyd's perforating vein is another clinically important perforating vein, located approximately 10 cm below the medial joint of the knee. Perforating veins, therefore, play a fundamental roll in the development of varicose veins.

8.2.5 The Venous Valvular System

The number of venous valves of the leg veins has been found to be decreased in patients with varicose veins when compared with patients without varicose veins [2]. Age or gender does not correlate with a decrease in valvular number. Therefore, other factors must contribute to the decrease in the number of venous valves. Additional potential mechanisms of valvular dysfunction contributing to varicose veins include fibrosis of these valves caused by turbulent high-pressure blood flow, a hereditary defect in either vein wall and/or valvular structure, and an increase in deep venous pressure (Table 8.1). Since competent venous valves are able to withstand pressures of up to 3 atmospheres, the normal vein diameter must first dilate in order to cause valvular incompetency [2]. Chronic venous dilation from chronic venous hypertension may likely produce stress on

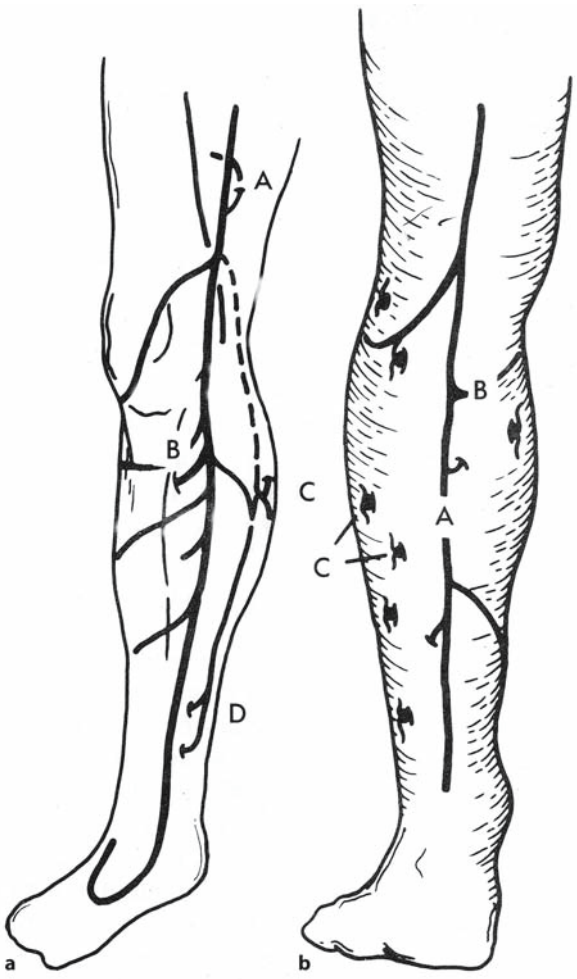


Fig. 8.3. a Typical course of the long saphenous vein (LSV), including its common tributaries and perforating veins. *A* Hunterian perforating vein, *B* posterior tibial perforating vein, *C* calf perforator in the location of the intrasaphenous vein, *D* medial ankle, or Cockett perforators. **b** Typical course of the SSV with termination above the popliteal fossae and associated perforator veins. *A* SSV, *B* intersaphenous vein with calf perforator, *C* paraperoneal perforating veins. (Reprinted with permission from Goldman MP (1991) *Sclerotherapy: Treatment of varicose and telangiectatic leg veins.* Mosby, St. Louis.)

the valvular system, leading to dysfunctional fibrosis of the valves(s) These dysfunctional valves lead to the development of valvular insufficiency, which in turn causes a reversal of blood flow from the deep venous system to the superficial veins through incompetent perforating/communicating veins. This reversal of flow by incompetent valves of perforating veins may be beneficial, however, during sclerotherapy. When a superficial varicosity is injected, the reversal of blood flow forces the direction of the sclerosant to flow distally to the smaller branching veins away from the deep veins thereby preventing thromboembolic disease of the deep venous system. In summary, pathologic development of incompetent valves and varicose veins can be divided into the following four categories: increased deep venous pressure, primary valvular incompetence, secondary valvular incompetence, and heredity factors.

8.3 Indications for Sclerotherapy

The objectives of sclerotherapy include the treatment of varicosities, telangiectasias, and/or reticular veins of the lower extremity (Tables 8.2 and 8.3) and prevention of possible complications; reduction or elimination of existing symptoms; improvement in altered hemodynamics; and achievement of a final result

Table 8.1. Factors involved in the development of varicose veins

Increased deep venous pressure
Proximal causes
Pelvic obstruction (indirect venous obstruction)
Increased intraabdominal pressure (straining at defecation or micturition, wearing constrictive clothing, prolonged standing, chair sitting, leg crossing, squatting, obesity, or running)
Saphenofemoral incompetence
Venous obstruction
Distal causes
Communicating or perforating vein valvular incompetence
Venous obstruction
Arteriovenous anastomoses
Primary valvular incompetence
Venous obstruction (thrombosis)
Thrombophlebitis with destruction of venous valves
Congenital absence of the venous valves (agenesis)
Decreased number of venous valves
Secondary valvular incompetence
Deep venous obstruction
Increased venous distensibility
Hormonal (pregnancy; estrogens, progesterone, and their relative concentrations)
Heredity
Vein wall weakness
Inherited deficiency of vein wall collagen
Primary valvular dysfunction / agenesis
ABO blood group

Source: This has been modified from Goldman MP (1991) *Sclerotherapy: Treatment of varicose and telangiectatic leg veins*. Mosby, St. Louis, p 56, with permission from the author

Table 8.2. Classification of abnormal veins

Vein type	Diameter	Color
Telangiectasia (spider veins)	0.1–1.0 mm	Red to cyanotic
Telangiectatic matting	<0.2 mm	Red
Communicating telangiectasia[a]	0.1–1.0 mm	Red to cyanotic
Telangiecatic and varicose vein mixture[b]	1.0–6.0 mm	Cyanotic to blue
Nonsaphenous varicose veins (reticular veins)	2–8 mm	Blue to blue-green
Saphenous varicose veins	>8 mm	Blue to blue-green

Source: This has been modified from Goldman MP (1991) *Sclerotherapy: Treatment of varicose and telangiectatic leg veins*. Mosby, St. Louis, p 56, with permission from the author

[a] Veins that communicate directly with varicose veins of the saphenous system
[b] Veins that do not communicate directly with the saphenous system

Table 8.3. Types of veins responsive to sclerotherapy

Truncal veins
Incompetent perforating veins
Communicating/side branch varicosities
Reticular veins
Venulectases
Telangiectasias (spider veins)
Postsclerotherapy and postsurgical recurrent varicose veins

that satisfies aesthetic and functional criteria [6]. Sclerotherapy is considered the first line of treatment for small, intracutaneous varicose veins (reticular varicose veins and telangiectatic veins). With regard to the elimination of collateral and incompetent perforating veins, sclerotherapy competes with phlebextraction and with ligation of perforating veins or endoscopic dissection of perforating veins. A discussion of these latter techniques is beyond the scope of this chapter. In the treatment of valvular insufficiency of truncal veins with elimination of the proximal leakage point, as well as the incompetent venous portion, surgery is currently considered to be the method of first choice. However, treatment of incompetent perforating veins and truncal veins, particularly by foam sclerotherapy, is also possible and promising, as will be later discussed.

8.4 Clinical Evaluation of the Venous System of the Lower Extremity

A screening examination of the venous system should be performed before performing sclerotherapy. Prior to treatment, the phlebologist must first investigate three conditions: the presence of poorly visible varicose veins proximal to or underlying the veins to be treated, deep venous or perforator valvular insufficiency, and deep venous thrombosis [5]. If there is a proximal source of superficial or deep venous reflux of blood, injection of distal telangiectasias solely will not defend against a recurrence. Subsequently, treatment of these "feeder" vessels may be necessary to ensure complete eradication of the problem. Successful sclerosis of superficial varicose veins may be rendered unsuccessful if perforating vein valvular insufficiency goes untreated. Perforating vein valvular insufficiency can lead to the development of other varicosities or telangiectasias. If the patient has deep venous valvular insufficiency, sclerotherapy of superficial varicose veins may also be inadvisable. In this setting, it is possible that the patient may encounter more severe pain when walking following sclerotherapy treatment, as the development of superficial varicose veins may have been a compensatory mechanism for an incompetent deep venous system. This is known as venous claudication [5]. Finally, because varicose veins are a risk for the development of deep venous thrombosis, a screening procedure to rule out this condition is required.

Examination of the venous system of the lower extremities can be performed without the aid of technologically advanced equipment. With the patient's entire leg exposed, visual inspection is performed. A diagram of the visual varicosities and telangiectasias, noting bulges and fascial defects, is recorded. Importantly, fascial defects may be associated with incompetent perforator veins 50–70% of the time [4]. With the patient's leg elevated, detection of fascial defects is performed by running the examiners finger along the course of a varicosity. Depressions within the subcutaneous tissue should be marked. Incompetence of these perforating veins can be detected by having the patient stand while the examiner holds pressure on these points. If the varicose vein fails to reappear with the patient standing, release of each finger, one at a time, distally to proximally, is performed. The release point at which the varicosity reappears is marked. This site represents the most distal incompetent perforating vein [4, 5].

A clinical sign of valvular incompetence of the saphenous venous system is demonstrated by palpating for an impulse over a segment of the greater saphenous vein when the patient coughs. The presence of an impulse with coughing implies incompetence of the valve(s) proximal to this segment (cough test) [2, 4].

The percussion/Schwartz test is performed by placing one hand over the saphenofemoral junction or the saphenopopliteal junction while the other hand is used to tap lightly on a distal portion of the long or short saphenous vein. The presence of an impulse implies valvular insufficiency in the segment between the two hands [2, 4]. Palpating over the long or short saphenous vein while tapping on a dilated tributary, or vice versa, can detect whether the tributary is in direct connection with the long or short saphenous vein. False negatives can be seen in patients with previous groin surgery, obesity, and in patients with variations in their venous anatomy.

Once the dilated veins of the leg are marked, the Brodie-Trendelenburg test can be performed. With the patient in the supine position and the leg elevated 60°, emptying the varices of blood by stroking distally to proximally is performed, and a tourniquet is placed around the proximal thigh. The patient then stands up, and the leg is observed for 30 s with the tourniquet in place. The following responses can be seen:

- "Nil" test: (Competent valves of the deep and perforating veins and at the saphenofemoral junction):
  No distention of the veins for 30 s both with the tourniquet in place and after removal
- "Positive" test: (Incompetent valve at the saphenofemoral junction):
  Distention of the veins only after release of the tourniquet
- "Double" positive test: (Incompetent deep and perforating veins, with reflux through the saphenofemoral junction):
  Distention of veins with the tourniquet in place and further distention after release
- "Negative" test: (Deep and perforating valvular insufficiency):
  Distention of veins within 30 s of the tourniquet in place, and no increased filling after release of the tourniquet. However, filling of the vein(s) after 30 s of tourniquet placement does not imply competence of perforating veins (Fig. 8.4) [2].

The Perthes' test is performed by placing a tourniquet around the proximal thigh with the patient in the supine position. Then, as the patient ambulates, a decrease in distension of varicosities implies a primary process without existing deep venous system disease. A constant distention implies a secondary process with impairment of the calf-muscle pump and deep venous patency, and an increase in distension implies deep venous obstruction [2, 4, 5].

Placing a tourniquet around the calf right below the popliteal fossae with the patient in the supine position can help to determine perforator valvular dysfunction. An indication of incompetent perforating veins occurs when the veins become more prominent and dilated as the patient ambulates [2, 4, 5].

These "hands-on" tests supply information but are not precise. These tests also do not recognize deep vein thrombosis and are not the most effective means of localizing abnormal valves. Discussion of noninvasive diagnostic techniques follows.

8.5 Diagnostic Examination of the Venous System of the Lower Extremity

Varicose vein disease is the abnormal functioning of the venous system of the lower extremity due to valvular dysfunction, which includes ectatic veins and varicosities. When considering sclerotherapy treatment, the phlebologist must first evaluate the patient to determine whether the venous segment is simply a case of telangiectatic veins or more serious varicose veins. The examination begins with the patient's venous history, including duration of condition, prior treatments such a sclerotherapy, ligation, phlebextraction, and endoscopic dissection,

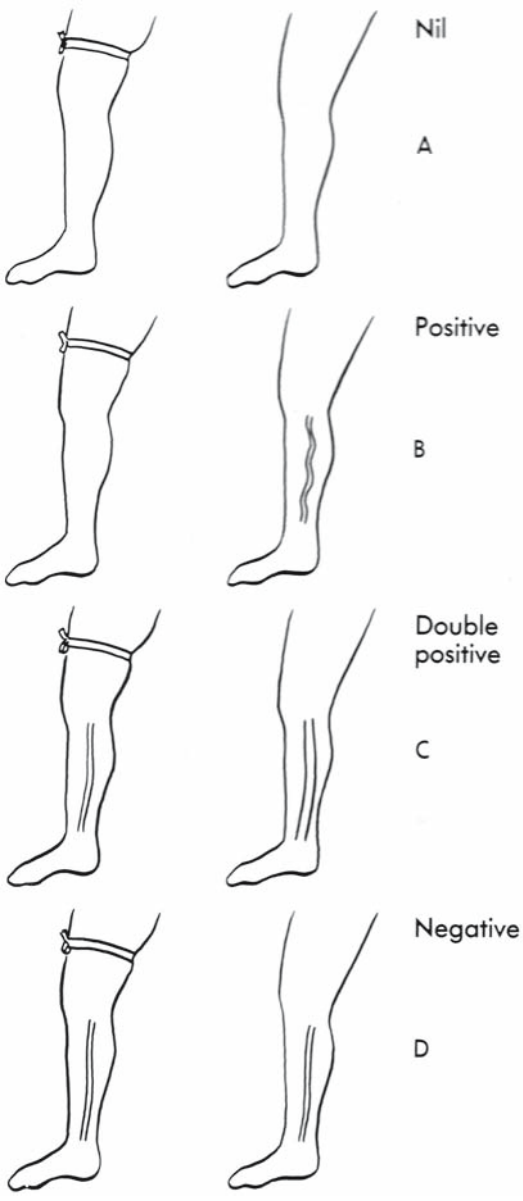


Fig. 8.4A–D. Interpreting the Brodie-Trendelenburg test. **A** Nil: no distention of the veins for 30 s both while the tourniquet remains on and also after it is removed implies a lack of reflux. **B** Positive: distention of the veins only after the tourniquet is released implies reflux only through the saphenofemoral junction (SFJ). **C** Double positive: distention of the veins while the tourniquet remains on and further distention after it is removed implies reflux through perforating veins as well as the SFJ. **D** Negative: distention of the veins while the tourniquet remains on and no additional distention once it is removed implies reflux only through perforating veins. (Reprinted with permission from Goldman MP (1991) *Sclerotherapy: Treatment of varicose and telangiectatic leg veins.* Mosby, St. Louis.)

any history of deep vein thrombosis or superficial thrombophlebitis, and the severity of symptoms and their affect on the patient, such as with extensive standing, walking or leg elevation.

Indications of varicose vein disease include:

- Pain and/or aching in the leg(s) that is alleviated with leg elevation, exercise, or compression hosiery
- History of phlebitis
- Large, long-standing varicose veins
- Abundance of telangiectatic veins near the medial malleolus
- Venous stasis dermatitis
- Ulceration
- Rubor

Patients who should be evaluated with venous Doppler ultrasound are those with hemodynamically significant varicose veins [5, 7, 8]. Also, the presence of a radiating flare of telangiectasias from a central point may indicate an underlying incompetent perforator vein [4]. Untreated deep venous or perforator valvular insufficiency may prevent successful sclerosis of the superficial varicose vein, or treatment may be contraindicated in cases where superficial varicosities serve as a compensatory mechanism. Poorly visible varicose veins proximal to or underlying the veins to be treated will also need to be investigated. Patient selection for examination with venous Doppler includes:

- Varicosities greater than 4 mm in diameter
- Any varicosity over 2 mm in diameter extending throughout the entire calf or thigh
- Any varicosity extending into the groin or popliteal fossae

- A "star-burst" cluster of telangiectasias, especially if over the usual points of perforating veins (midposterior calf, medial knee, medial midthigh, medial distal calf)
- Previous venous surgery or sclerotherapy with poor results or recurrence of varicosities
- Obesity

Instrumentation for the lower-limb Doppler examination should use ultrasound imaging frequencies in the 5- to 10-MHz range [4, 5, 7, 8]. Generally, a 7.5- to 10-MHz imaging probe is used to visualize superficial and perforating veins, and a 5- to 7.5-MHz probe is used for imaging deep and muscle veins [5]. The five important Doppler features of blood flow in normal veins are listed in Table 8.4.

Continuous wave Doppler ultrasound emits a continuous beam of ultrasound waves that detect red blood cells moving within the vessel. Sound waves reflect back to the receiving probe at a different frequency. This change in frequency is converted to an audible sound. Frequencies in the 7- to 10-MHz range are optimal for examining superficial vessels whereas lower frequencies (5–7 MHz) are required for examination of deeper vessels. When incompetent valves are present, compression of the muscles proximal to the Doppler probe produces a long sound while blood flows unhindered distally through incompetent valves [4]. When compression is released, flow stops, as does the emitted sound. During compression of incompetent valves distal to the probe, normal proximal flow is heard, but when compression is released, blood flows distally emitting a prolonged sound because incompetent valves cannot prevent retrograde flow [4, 5].

Table 8.4. Important Doppler features of blood flow in normal veins

1. Spontaneous flow in the proximal deep veins with the patient at rest
2. Phasic flow with respiration
3. Cessation of blood flow in response to the Valsalva maneuver
4. Augmentation of blood flow by circumferential compression of the extremity distal to the site of Doppler examination
5. Unidirectional flow towards the heart

The deep venous system is evaluated for acute or chronic damage to the valvular system and for the presence of deep vein thrombosis. Demonstration of normal, one-way flow at the iliofemoral junction in the groin, the popliteal vein in the popliteal fossae, and the posterior tibial vein in the medial malleolar region should be evaluated in a warm room to reduce venoconstriction and with the patient lying down. Examination of the superficial venous system is usually performed with the patient standing.

Examination of the superficial venous system begins with the patient in the standing position, which will enhance ultrasound imaging. The examination is facilitated with the patient standing on a stool (approximately 6 in. off the floor). With the patient bearing weight on the opposite extremity, the limb under study is abducted at the hip with the knee slightly flexed. The common femoral vein in the groin is imaged first and followed proximally to image the external iliac vein. Doppler recordings are taken during the Valsalva maneuver with spontaneous and phasic flow and with manual calf or thigh compression and release. The vein should be imaged in the sagittal plane with the angle of the Doppler probe less than 60°. Reflux is designated by a reverse flow signal for longer than 0.5 s after release of compression. Similar studies and maneuvers are performed on the common femoral vein. The saphenofemoral junction is next identified. The long saphenous vein just distal to this junction is examined during calf or thigh compression and release. During a Valsalva maneuver, a continuous and pronounced reflux signal is a reliable sign of valvular insufficiency. However, mild and brief reflux can be found in 15% of normal individuals. An equivocal result may require a Duplex ultrasound (DUS) examination [4].

Assessments of long saphenous vein competence in the proximal, mid, and distal thigh are then performed. Assessments with calf compression are made. During the thigh exam, any

perforating veins penetrating the muscle fascia that communicate with the long saphenous system and femoral vein should be examined. Perforating veins should be assessed for competency. Incompetence of perforator veins exists if there is deep-to-superficial flow for longer than 0.5 s on manual compression above or below the ultrasound transducer [9]. The popliteal vein is examined in three segments: distal to, proximal to, and at the same level of the saphenopopliteal junction. The saphenopopliteal junction, if located, should be assessed. The short saphenous vein is examined for competence in the proximal, mid, and distal calf segments. Examination of the medial and lateral calf veins takes place with the patient sitting with the leg extended horizontally and the foot resting on the examiner's knee with the calf muscle relaxed. Assessment of the proximal calf segment of the long saphenous vein is examined for competence and patency from the knee to ankle. The posterior arch vein can also be located and assessed in most patients. Calf-perforating veins from the posterior arch complex (gastrocnemius and soleal perforators or posterior tibial perforators) can be identified and examined for competency by compression above and below the transducer [9].

Deep-to-superficial blood flow greater than 0.5 s on calf or foot compression is considered incompetent. Distal segments of the gastrocnemius vein can similarly be assessed. Doppler studies should also be performed on the posterior tibial vein from the proximal calf to the ankle. The peroneal vein is examined from the same transducer position. The anterior tibial vein only needs assessment in suspected cases of deep venous thrombosis. Routine assessment of the lateral calf and soleal veins is unnecessary unless there are obvious lateral calf varices [9].

Duplex venous scanning is the most advanced modality used to investigate venous disease in the sclerotherapy patient. Duplex scanning is important in the clinical decision-making process as well as being useful in the serial assessment of disease progression and treatment effectiveness. Duplex sonography combines venous Doppler blood flow analysis with pictorial anatomic information of ultrasonography. This system is commonly used for evaluation of the deep venous system for thrombosis. Most technicians can accurately evaluate the superficial venous system as well, including detection of blood flow and velocity and vessel structure and diameter. The scanning device involves a B-mode imaging ultrasound probe combined with a 3-MHz directional pulsed Doppler ultrasound [9]. Visual assessment of blood flow is made possible with color-duplex imaging, which superimposes blood flow information from the pulsed Doppler onto the B-mode ultrasound image. Color duplex stands apart from the standard duplex instrument because color duplex allows for both anatomic structures and flow patterns to be visualized in one image, allowing the vessel to be located and followed more easily than with standard duplex instrumentation [9]. Blood flow is displayed in color while stationary anatomic structures are represented in shades of gray [9].

Areas of phlebology where duplex examination is essential as a diagnostic tool include the diagnosis and evaluation of the extent of deep venous thrombosis. Accuracies of over 90% have been achieved in the femoropopliteal segment and in 80% of the diagnosis of calf vein thrombosis [9]. Another application of duplex examination is in the evaluation of deep and superficial venous insufficiency. This pretreatment evaluation will ensure that all significant areas of reflux are addressed. Duplex scan is the most important diagnostic tool in the management of recurrent varicose veins where primary anatomy is altered by previous surgical procedures. Duplex examination is also utilized to accurately guide sclerosant injections into incompetent perforator and impalpable superficial axial incompetent veins and reduce adverse effects, including intraarterial injections and deep venous thrombosis [7–9]. And finally, duplex examination is used in saphenous vein mapping prior to procedures such as coronary bypass surgery to ensure venous patency, size (diameter greater than 3.0 mm), and length, and to confirm that the long saphenous vein is not serving as collateral circulation in chronic deep venous insufficiency [9] (Tables 8.5, 8.6).

Table 8.5. Diagnostic evaluation of the venous system of the lower extremity

	Preferred method	Pitfalls	Additional methods
Deep veins	Doppler ultrasound	Differentiation SFJ versus CFV SPJ versus popliteal vein	PPG/LRR Venography Duplex
Saphenous trunks	Doppler ultrasound	Differentiation SFJ versus CFV SPJ versus popliteal vein	Percussion Trendelenburg Venography Duplex
Tributaries of saphenous trunks	Doppler ultrasound	N/A	Percussion Duplex
Perforating veins	Clinical exam and Doppler ultrasound	50–80% accurate	Venography Duplex Thermography Fluorescein
Contribution of superficial versus deep reflux	PPG/LRR	N/A	AVP Duplex velocities
Functional evaluation	PPG/LRR	N/A	AVP Foot volumetry
Vulvar varices	Clinical exam for LSV reflux	N/A	Varicography

PPG photoplethysmography, *LRR* light reflection rheography, *SFJ* saphenofemoral junction, *CFV* common femoral vein, *SPJ* saphenopopliteal junction *AVP* ambulatory venous pressure, *LSV* lesser saphenous vein

Table 8.6. Doppler ultrasound versus duplex scanning

	Doppler	Duplex
Portability	Portable	Not easily portable "Luggable" units available
Ease of use	Requires short period of training and experience	Requires longer period of training
Cost (approximate)	Unidirectional: $300 Bidirectional: $2,500	Grey scale: $40,000 Color: $150,000 and up
Information obtained	1. Patency, competence of venous valves 2. DVT in thigh (? calf)	1. Patency, competence of venous valves 2. DVT with greater accuracy 3. Velocity of reflux 4. Anatomy and anomalies of venous system 5. Termination of SSV 6. Thrombosis versus sclerosis
Reliability	Less reliable because of blind, nonpulsed sound beam	More reliable because of actual visualization of vein being examined

DVT deep vein thrombosis, *SSV* short saphenous vein

8.6 Treatment of Telangiectasias

Telangiectasias and varicose veins less than 2 mm in diameter may safely and effectively be treated with sclerotherapy alone (Fig. 8.5). However, it is important to emphasize that thorough assessment for any significant underlying incompetent vessels be completed first.

8.6.1 Venous Segment Preparation

Sclerotherapy of telangiectatic veins should be performed with the patient in the supine position and the phlebologist comfortably seated. The surface of the injection site should first be drenched with 70% isopropyl alcohol. This not only cleanses the site, but it also enhances visualization of the telangiectasia(s) because alcohol changes the index of refraction of the skin

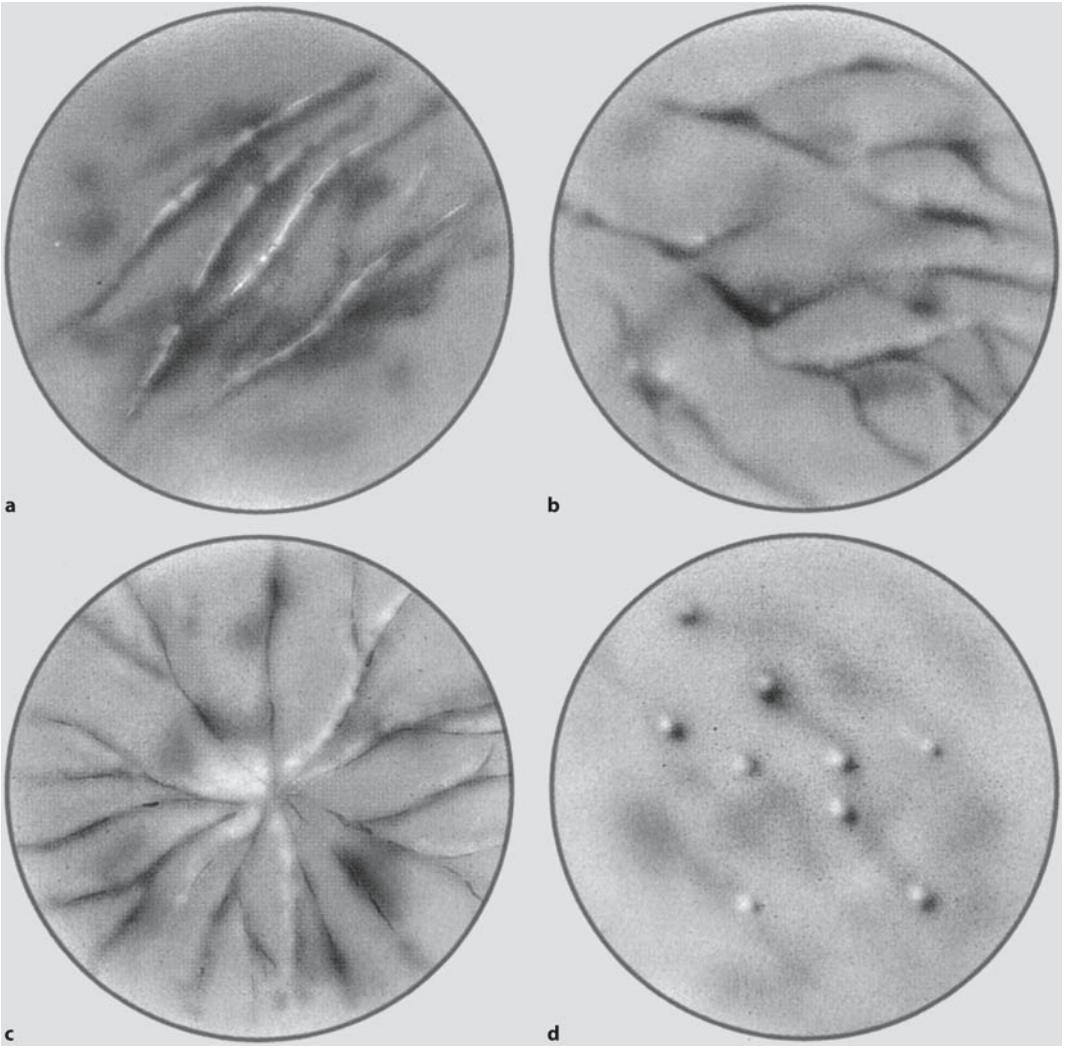


Fig. 8.5a–d. Four types of telangiectasias: **a** Simple, **b** arborized, **c** spider, **d** papular. (Reprinted with permission from Goldman MP (1991) *Sclerotherapy: Treatment of varicose and telangiectatic leg veins.* Mosby, St. Louis.)

causing it to become more transparent. Additionally, the alcohol may also cause vasodilatation of the telangiectasias [2]. Alternative techniques used to enhance visualization include wiping the skin with a solution composed of 70% isopropyl alcohol and 0.5% acetic acid, recommended by Sadick who found this solution to better improve the angle of refraction than alcohol alone, and by rubbing a very small amount of the sclerosing solution into the skin, as practiced by Scarborough and Bisaccia [2]. These phlebologists also use Aethoxysklerol (polidocanol), which contains alcohol [2]. Magnifying devices with a 2+ or 3+ diopter should also be used to further enhance visualization of the telangiectasia(s) (Table 8.7). The use of a lamp, or any other source of direct lighting, over the injection site should be avoided because this will produce a glare. Visualization is maximized with indirect, shadow-free lighting.

To distend the diameter of vessels that appear to be too small for injection, either the pa-

Table 8.7. Sclerotherapy supplies and distributors

Supplies	Distributors
Magnifying glasses	Clip-on Loupes: Almore International Portland, OR 97225, USA Opticald: Edroy Products Co., Inc. Nyack, NY 10960, USA
Headband-mounted simple binocular magnifiers	Mark II Magni-Focuser: Edroy Products Co., Inc. Nyack, NY 10960, USA Optivisor: Donegan Optical Company 15549 West 108th Street Lenexa, KS 66219, USA
Simple binocular loupes	Multidistance Headband Loupe: Edroy Products Co., Inc. Nyack, NY 10960, USA Precision Binocular Loupe: Almore International Portland, OR 97225, USA
Binocular loupes	Design for Vision New York, NY 10010, USA N1064 Oculus: Storz Instrument Company St. Louis, MO 63122, USA Westco Medical Corporation San Diego, CA 92138, USA See Better Loupe: Edroy Products Co., Inc. Nyack, NY 10960, USA
Syringes	Luer Lok or non-Luer Lok: Becton-Dickinson & Company Rutherford, NJ 07070, USA Plastipak Eccentric Syringe: Becton-Dickinson & Company Rutherford, NJ 07070, USA

Table 8.7. Continued

Supplies	Distributors
Material for foam generation	Injekt syringe with Luer-Lock (green) 10 ml, for foam generation; No. 4606728 B, BRAUN, Melsungen Combidyn adapter, f/f, for the safe connection of the syringes during foam generation; No. 5206634 B, BRAUN, Melsungen Omnifix syringe with Luer-Lock 10 ml, for foam generation; No. 4617100 B, BRAUN, Melsungen www.bbraunusa.com/ 824 Twelfth Ave., Bethlehem, PA 18018, USA
Material for sterile filtration of ambient air	Sterifix 0.2 µm sterile filter no. 4099206 B, BRAUN, Melsungen www.bbraunusa.com/ 824 Twelfth Ave., Bethlehem, PA 18018, USA
Compression hosiery	Camp: Camp International, Inc. P.O. Box 89 Jackson, MI 49204-0089, USA Jobst: The Jobst Institute, Inc. P.O. Box 652 Toledo, OH 43694, USA JuZo: Julius Zorn, Inc. (JuZo) P.O. Box 1088 Cuyahoga Falls, OH 44223, USA Legato: Freeman Manufacturing Co. 900 W. Chicago Rd. Sturgis, Michigan 49091-9756, USA Medi: Medi USA (American Weco) 76 W Seegers Rd. Arlington Heights, IL 60005, USA Sigvaris: Sigvaris P.O. Box 570 Branford, CT 06405, USA Venosan: Freeman Manufacturing Co. 900 W Chicago Rd. Sturgis, Michigan 49091-9756, USA
Foam pads	Reston: 3M Health Care St. Paul, MN 55144-1000, USA or: D-46325 Borken, Germany STD Pharmaceutical Field Yard, Plough Lane Hereford HR4 0EL, UK
Color-duplex scanner	Apogee 800: Advanced Technology Laboratories Solingen, Germany

Table 8.7. Continued

Supplies		Distributors
Needles	21-, 23-, or 25-gauge butterfly	Abbott Hospitals, Inc. North Chicago, IL 60064, USA Surflo Winged Infusion Set: Terumo Corporation Tokyo, Japan
	26- or 27-gauge	Allergy: Becton-Dickinson & Company Ft. Lauderdale, FL 33314, USA Yale: Becton-Dickinson & Company Ft. Lauderdale, FL 33314, USA
	30-gauge	Acuderm: Acuderm, Inc. Ft. Lauderdale, FL 33314, USA Delasco: Dermatologic Lab and Supply, Inc. Council Bluffs, IA 51503, USA Precision Glide: Becton-Dickinson & Company Rutherford, NJ 07070, USA
	33-gauge	Delasco: Dermatologic Lab and Supply, Inc. Council Bluffs, IA 51503, USA Hamilton: Hamilton Company Reno, NV, USA (800) 648-5950
Tape dressings	Localized pressure	Coban Tape: Medical Surgical Division/3M St. Paul, MN 55144, USA Medi-Rip Bandage: Conco Medical Company Bridgeport, CT 06610, USA
	Minimal pressure	3M Microfoam Surgical Tape: Medical Surgical Division/3M St. Paul, MN 55144, USA Tubigrip Tubular Support Bandage: Seaton Products, Inc. Montgomeryville, PA, USA

tient stands for 5 min and is then placed in the Trendelenburg position or a blood pressure cuff is inflated to approximately 40 mmHg proximal to the injection site while the patient is supine.

8.6.2 Sclerotherapy Technique for Telangiectasias

When performing sclerotherapy, the skin should be held taut to facilitate cannulating the vessel. This can be achieved by stretching the skin in opposite directions perpendicular to the vessel with one hand. Then, with the opposite hand that is holding the syringe, the fifth finger

is used to stretch the skin in a third direction away from the vessel. These three tension points ensure that the skin is taut and ready for injection (Fig. 8.6). The ultimate goal is to enter the vessel and inject the sclerosant within, and not outside, the vessel wall [2]. A 30-gauge needle will usually yield the desired results, with maximum comfort for the patient as well. However, some phlebologists recommend using either a 32- or 33-gauge stainless steel needle for the intravascular injection of smaller telangiectatic vessels, even though these needles are nondisposable, require sterilization, and dull and bend easily. Also recommended is a 3-ml syringe filled with 2 ml of sclerosant, as this allows for slow, low-pressure injection of the sclerosing solution and avoids "blow-out" of the vessel and extravasation. Each injection should take approximately 5–15 s [1]. The 3-ml syringe is also an ideal size and can be manipulated easily (Table 8.7) [2].

I prefer to aspirate enough air to occupy the needle hub prior to injecting. The air that enters the vessel displaces the blood and assures that the needle is in the vein. If a diffuse urticarial-like blanching is observed, the needle is not in the lumen (the air has entered the surrounding tissue). Additionally, as the air pushes the blood through the vessel, the sclerosant makes undiluted contact with the intima, maximizing irritation. Missing the lumen is probably due to the needle being under and not within the vessel.

Since most telangiectatic leg veins are located in the superficial dermis of the skin, I recommend placing the needle flat against the skin and penetrating the skin almost parallel to the surface. To ensure depth of penetration and that the vessel is not exceeded, the needle should be bent approximately 45° with the bevel up (Fig. 8.7) [2]. Injecting the vessel with the bevel up lessens the chance of transection. With proper technique and magnification, visualization of the bevel/tip of the needle through the skin and into the vessel is possible to ensure correct placement within the vessel lumen. Further advancement is not required or recommended. Whether sclerotherapy should pro-

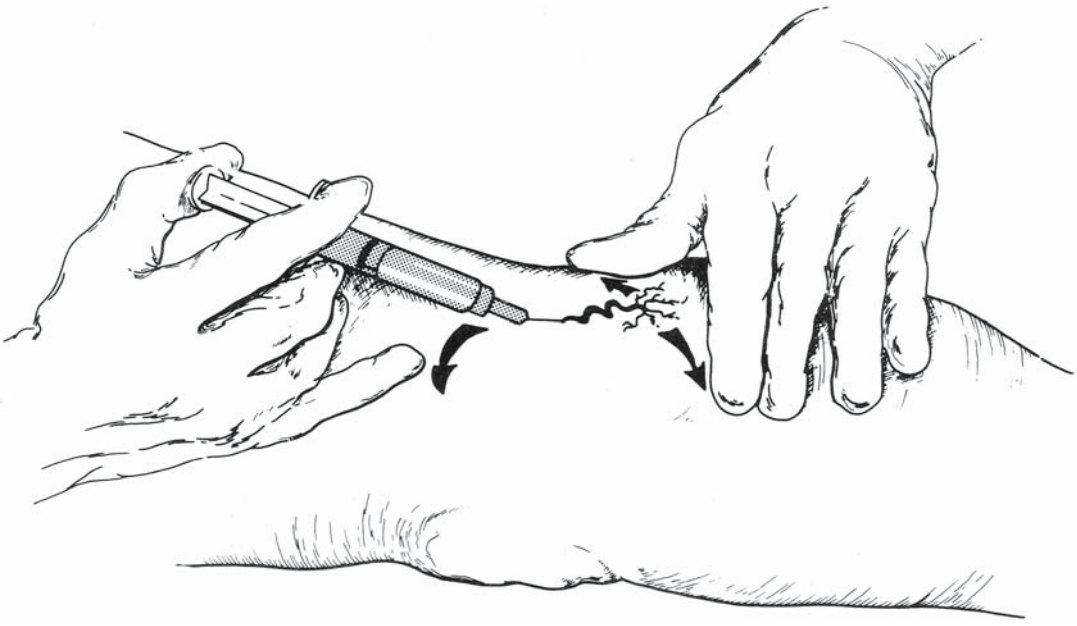


Fig. 8.6. Illustration of proper hand placement to exert three-point traction to aide in needle insertion. Injection is made into the feeding "arm" of the "fingers" of the spider vein. (Reprinted with permission from Goldman MP (1991) *Sclerotherapy: Treatment of varicose and telangiectatic leg veins.* Mosby, St. Louis.)

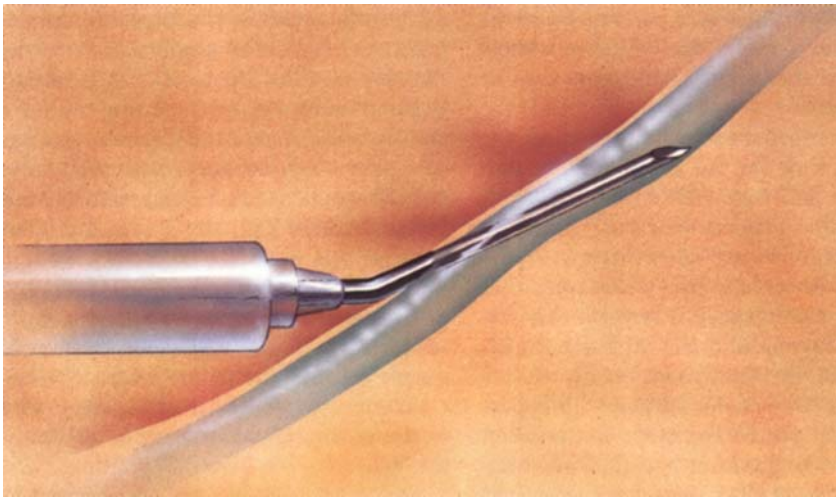


Fig. 8.7. The needle is bent to 45° with the bevel up to facilitate accurate insertion into the superficial telangiectasia. (Reprinted with permission from Goldman MP (1991) *Sclerotherapy: Treatment of varicose and telangiectatic leg veins.* Mosby, St. Louis.)

ceed proximally to distally (the French school), distal to proximal (the Swiss school), or random-site injection, is acceptable and under ongoing discussion. Injecting the most proximal "feeder" vessel in a telangiectatic cluster is preferred. I also advise injecting the "straightest" and largest vessel within the cluster, no matter the direction of orientation, to avoid vascular transection. Edema (urticarial) and erythema become apparent in 2–30 s postinjection and may last 30 min to several hours. The patient may also complain of muscle cramps in the calf or thigh with hypertonic saline and hypertonic glucose/saline injections. This usually lasts less than 3 min, and the patient should be forewarned. Gentle massaging may help with cramping. A bleb at the site of the needle may appear during injection. Removal of the needle and application of digital massage should be performed immediately. I prefer to inject a generous amount of normal saline or 1% lidocaine if this occurs to reduce the pain and help dilute the sclerosant in the tissue. These small infiltrates may leave small brown macules, which usually disappear in 3–12 weeks. It is important to watch the needle site while injecting, rather than the course of the sclerosing solution through the vessel, and to avoid pushing the injecting hand forward while pushing the plunger. If the injection site and needle placement are carefully monitored, then extravasation can be limited. Repeat treatment on persistent vessels can be performed as early as 3 weeks after the previous treatment. Larger-diameter vessels (greater than or equal to 2 mm) may thrombose. This is easily recognized when the patient returns for follow-up and may be apparent as early as 1 week postsclerotherapy. The vessel appears bluish-purple and does not blanch under pressure. Treatment consists of making a small "stab" incision over the vessel with a number 11 blade and milking out the dark, syrupy blood. The wound is covered with a topical antibiotic ointment and bandage and usually heals well. Maximum recommended dosages of sclerosants vary with the different types and concentrations (Tables 8.8 and 8.9). Many phlebologists recommend a treatment session time of approximately 15–30 min and not more than 12 cc of sclerosant per session [10]. Sclerotherapy requires great concentration and a steady hand. Clinician fatigue greatly reduces efficacy.

Compression should be applied to the injected site immediately postinjection. Massaging the injected vein(s) immediately after with-

Table 8.8. Sclerosing agents

Classes	Agents	FDA approval	Ingredients	Advantages	Disadvantages
Osmotic agents	Hypertonic saline	Approved abortifacient	18–30% saline	Lack of allergenicity	Damage to cellular tissues Produce ulcerations Necrosis Hyperpigmentation Pain Muscle cramping
	Hypertonic glucose/saline (Sclerodex)	Not approved	250 mg/ml of dextrose, 100 mg/ml of sodium chloride, 100 mg/ml of propylene glycol, and 8 mg/ml of phenethyl alcohol	Minimized pain Less muscle cramping	Superficial necrosis Allergic reaction Hyperpigmentation Mild pain
Chemical irritants	Chromated glycerin (Scleremo)	Not approved	1.11% chromated glycerin	Rare posttreatment hyperpigmentation, necrosis, and bruising, even if injected extravascularly	Weak agent, therefore requires more treatment sessions High viscosity Pain
	Polyiodinated iodine (Variglobin, Sclerodine)	Not approved	A water solution of iodide ions, sodium iodine, and benzyl alcohol	Direct destruction of the endothelium	Necrosis Pain
Detergent sclerosing solutions	Sodium morrhuate	Approved	Sodium salts of the saturated and unsaturated fatty acids in cod-liver oil	N/A	Extremely caustic Necrosis Allergic reactions, including anaphylaxis Pain
	Ethanolamine oleate (Ethamolin)	Not approved	Ethanol amine and oleic acid	Decreased risk of allergic reaction	Hemolysis[a] Renal failure with recovery[a] Constitutional symptoms[a] Pulmonary toxicity Allergic reactions Pain
	Sodium tetradecyl sulfate	Approved	Sodium 1-isobutyl-4-ethyloctyl sulfate, benzoyl alcohol 2% (anesthetic), and phosphate	N/A	Epidermal necrosis Allergic reaction Hyperpigmentation[b] Pain
	Polidocanol (Aethoxysklerol)	Pending	Hydroxypolyethoxydodecane, distilled water, and ethyl alcohol	Will not produce ulcerations Necrosis is very rare Allergic reaction is very rare Less hyperpigmentation Painless	Necrosis (rare)[a] Allergic reaction (rare)

[a] Dose related [b] Posttreatment hyperpigmentation is worse than with that of all other sclerosing solutions

Table 8.9. Recommended concentration/volume of sclerosing solutions

Agents	Vein diameter	Recommended concentrations	Recommended maximum quantity injected per treatment session
Chromated glycerin (Scleremo)	<0.4 mm	50% 100%	N/A
Ethanolamine oleate (Ethamolin)	20.4–0.5 mm 20.6–2 mm	2% 5%	<12 ml
Hypertonic glucose/ saline (Sclerodex)	0.4–0.5 mm 0.6–2 mm	N/A	10 ml; 1 ml per injection site, with 5 cm between each site
Hypertonic saline	20.4–0.5 mm 0.6–2 mm	11.7% 23.4%	N/A
Polidocanol (Aethoxysclerol)	20.4–0.5 mm 0.6–2 mm 3–5 mm >5 mm	0.25% 0.5% 0.75% 1–2% 3–5%	10 ml of a 6% solution
Polyiodinated iodine (Sclerodine) (Variglobin)	0.4–0.5 mm 0.6–2 mm 3–5 mm >5mm	0.1% 1% 2% 3–12%	3 ml of a 6% solution
Sodium morrhuate	20.4–0.5 mm 0.6–2 mm 3–5 mm	1% 2.5% 5%	N/A
Sodium tetradecyl sulfate	20.4–0.5 mm 0.6–2 mm 3–5 mm >5 mm	0.1% 0.25% 0.5–1% 2–3%	4 ml of a 3% solution by British manufacturers, and 10 m of a 3% solution by United States and Canadian manufacturers

drawing the needle, using firm pressure and "milking" the sclerosant toward the smallest telangiectatic branches, provides immediate compression and decreases the chance of sclerosant and venous blood reflux from the puncture site and into the surrounding tissue. Massaging may also limit bruising and minimize stinging and burning. Adequate compression following each sclerotherapy session is essential for optimization of both short- and long-term treatment results. Direct contact of the sclerosed endothelium via compression results in more effective fibrosis and allows for the use of lower concentrations of sclerosant [11, 12, 13]. Compression also reduces the extent of thrombus formation, which in turn decreases the incidence of vessel recanalization. Postsclerosis hyperpigmentation and telangiectatic matting (TM) have also been shown to be reduced with the use of postsclerotherapy compression [12, 14]. Compression following treatment also improves efficacy of the calf-muscle pump and aids in more rapid dilution of the sclerosant from the deep venous system, thereby reducing the risk of deep venous thrombosis [2, 11, 12].

Patients who undergo sclerotherapy for uncomplicated telangiectasias usually can wear lighter-weight, graduated compression stockings (class I, 20–30 mmHg). These garments are applied at the end of the treatment session, with the treated leg(s) elevated approximately 45° above the horizontal. Additionally, postsclerotherapy cotton balls or rolls or foam pads are applied over the larger treated vessels and ap-

plied firmly in place with adequate pressure with a wide elastic bandage prior to application of the graduated compression garment (Table 8.7). Intravascular clots and phlebitis often occur when larger vessels are not additionally compressed with padding. Some phlebologists advocate removal of the compression garment 6 weeks after sclerotherapy, while others advocate wearing compression for no more than 8 h postsclerotherapy [10, 11, 12, 13]. Those who advocate 8 h of postsclerotherapy compression for telangiectasias feel the final outcome is no different than with patients who wear compression for 6 weeks [14]. The general recommended duration for wearing compression stockings varies from 3 days to 6 months, depending on–among other things–the diameter of the vessel(s). Studies show the maximum benefits of compression garments, no matter how long they were worn, were seen between 3– 6 months following treatment [12]. The most improvement was seen in patients who wore the compression stockings for 6 months. However, some improvement can be seen in patients who wear the compression stockings for only a few days [12]. Some phlebologists give the patient the option of wearing graduated compression stockings for a period of 1–3 weeks, after expressing to the patient that optimization of treatment is reached with a longer duration of compression. In general, small telangiectasias less than 1 mm in diameter may not require any postsclerotherapy compression [6].

After completion of the sclerotherapy session, the patient should walk for approximately 10–30 min immediately following the procedure. The patient should maintain normal day and nighttime activities, including at least a 1 h walk per day for 1 week. Hot showers or baths and strenuous physical activity (aerobics, weight lifting, squatting, etc.) should be avoided for the first week after treatment. Sclerotherapy is considered the standard treatment for intracutaneous varicose veins (spider, telangiectatic, and reticular veins), with an 80–90% improvement rate [15].

8.7 Sclerotherapy Techniques for the Treatment of Varicose Veins

Varicose veins usually develop from reticular veins or larger veins (including the saphenous veins and their tributaries) that reside in or below the subcutaneous fat [12]. The production of an intravascular thrombus produced by sclerotherapy has generally been felt to be a prerequisite for successful varicose vein sclerosis. However, the presence of an intravascular thrombus can serve as an impediment to complete resorption of the vein as a result of subsequent vessel-wall repair and recanalization [3]. Often, it may be more than a year before the recanalized, reconstituted vein can be visibly or palpably discerned [3]. Intravascular thrombosis is minimized utilizing the ultrasound-guided microfoam sclerosing technique, which "pushes" the blood out of the vessel segment, and by applying post-injection-sustained compression to the treated vein. Immediate and sustained compression minimizes the duration required for complete resorption of the vein because adequate compression applied immediately postinjection diminishes the volume of the intraluminal thrombus, even if full-thickness mural destruction has occurred [3]. The goal of varicose vein sclerotherapy, therefore, is transformation of the target vessel into a fibrous chord without the possibility of recanalization.

Varicose vein sclerotherapy requires thorough pretreatment evaluation and planning. Proper patient selection is critical and should include a history and physical examination appropriate for the extent of venous disease and, when indicated, laboratory studies to rule out altered coaguable states [16] (Table 8.10). The patient should also be educated about the procedure, including limitations, alternative treatments, potential adverse side effects, risks, and complications (Table 8.11). Baseline and follow-up photographs are useful to document the clinical extent of disease, location of treatment vessels, any preexisting pigmentation or scarring, and postsclerotherapy outcome and response to treatment. DUS, ve-

Table 8.10. Contraindications to sclerotherapy treatment

Absolute
Acute superficial or deep vein thrombosis
Advanced peripheral arterial occlusive disease (stages 3 or 4)
Confinement to bed
Hyperthyroidism[a]
Immobility
Known allergy to the sclerosant
Local infection in the treatment site, or severe generalized infection
Pregnancy[b]
Severe systemic disease
Relative
Allergy to heparin or aspirin
Bronchial asthma
History of coagulopathies
Inability to ambulate
Late complications of diabetes
Leg edema
Marked allergic diathesis
Peripheral arterial occlusive disease (stage 2)
Poor general health
Thrombophilia with history of deep vein thrombosis
Use of medications that may affect clotting mechanisms or platelet functions (estrogens, progesterones, etc.)

[a] Only when sclerosing agent contains iodine
[b] Within the first trimester and after the 36th week of gestation

Table 8.11. Complications and risks of sclerotherapy

Allergic reaction, including anaphylaxis
Hyperpigmentation
Necrosis
Nerve damage
Orthostatic hypotension
Scintillating scotomas
Telangiectatic matting
Thromboembolism
Thrombosis (deep or superficial) pulmonary embolism
Thrombophlebitis

nous Doppler studies, photoplethysmography (PPR), light-reflection rheography (LRR), air plethysmography, and other diagnostic studies should be reserved for appropriate patients with symptoms of venous disease, large diameter vessels (greater than 4 mm in diameter), or large numbers of telangiectasias indicative of venous hypertension (Table 8.5). The routine use of these expensive modalities in the presence of limited numbers of telangiectasias or vessels less than 1 mm in diameter is discouraged [16]. Diagnostic studies may be appropriate in patients with exacerbation or rapid recurrence of their disease process after sclerotherapy.

There are no uniformly agreed upon techniques or standards available for sclerotherapy of large varicose veins. A common assumption exists that veins larger than 10 mm in diameter are scleroresistant and require surgical removal, especially when associated with saphenofemoral incompetence. However, Kanter has nicely demonstrated that treatment of these large-caliber incompetent veins utilizing ultrasound-guided sclerotherapy (UGS) and 3% sodium tetradecyl sulfate (STS) is possible, with an overall recanalization rate of 10% at 2-year follow-up [7, 8]. Furthermore, Kanter also showed that injection of a 2-ml volume of sclerosant is less effective and is associated with more side effects than a 1-ml volume of sclerosant [8]. Sclerotherapy is generally performed in order of leakage points and from the largest to smallest varicose vein(s), proximal to distal. Recommended concentrations and volumes of sclerosants are listed in Table 8.9. A smooth-moving, disposable or glass 3-cc syringe is required for sclerotherapy, as well as a half- to 1-inch long small diameter cannula or butterfly catheter (23–27 gauge). The various concentrations of the sclerosant used should be carefully labeled on each syringe prior to use. Cotton balls or other padding, and precut tape attached to the side of the surgery tray, should be readily available. Equipment and medications for use in case of allergic reactions should also be on hand. DUS scanning during sclerotherapy allows the phlebologist to precisely locate and treat the pathologic components of the venous system under direct observation and is far

superior to the handheld Doppler, especially when sclerosing incompetent saphenous junctions, adjacent truncal veins, and perforating veins [15] (Tables 8.5 and 8.6). Although cannulation of the treatment vessel can be performed with the patient standing, injection of the sclerosant is usually performed with the patient in the horizontal position. Areas of reflux are identified with Doppler or duplex scanning and prepped prior to injection. The venous segment to be treated is punctured, preferably during UGS or DUS visualization, so that the intravascular injection can be controlled. When treating saphenofemoral incompetence, the injection site should not be less than 3–4 cm distal to the saphenofemoral junction to prevent injection into the femoral vein [7]. Visualization by DUS scanning ensures that the sclerosant is prevented from actually being deposited at the level of the saphenofemoral junction into the femoral vein [3]. However, even if the sclerosant enters the femoral vein, significant mural damage is unlikely because of the rapid dilution associated with the large volume of intravascular blood and the dynamic rate of flow in the vein [3]. Some authors recommend intermittent compression postinjection utilizing the ultrasound transducer [15]. Compression with the probe provides assessment of venous spasm as well as the length of sclerosis of the treated segment. The treatment of large varicose veins requires greater volumes and higher concentrations of sclerosant than smaller ectatic veins [7, 8]. Volumes ranging from 1 to 12 ml per injection site have been recommended. Each milliliter of sclerosant should be injected over an 8- to 15-s period, with 30- to 90-s intervals between injections. Immediate and sustained postinjection compression should be performed. The procedure is repeated proximally to distally along the vessel at approximately 5- to 10-cm intervals for a maximum total volume of 15 ml. A "second look" DUS examination, repeated 1–2 min postinjection, can reveal any persistently patent segment(s) for reinjection, provided the recommended volume of sclerosant has not been exceeded. Immediately postsclerotherapy, class II (30–40 mmHg) or class III (40–50 mmHg) graduated thigh-high, compression stockings are applied with the patient's legs elevated approximately 45°, along with focal padding over treated areas. Sustained postsclerotherapy compression may be required for 2–8 weeks or, rarely, longer, with a class II or class III graduated compression garment to be worn while awake. Local compression with padding or foam can be removed as early as the same evening, according to some authors, or several days to weeks later. Currently, there is no general agreement regarding duration or type of compression. I prefer the use of a self-adhesive foam padding manufactured by 3M (Reston self-adhering foam pad) and class II thigh-high graduated compression stockings to be worn for 1 week. Patients should be instructed to walk posttreatment (the recommended length of time currently is not defined). Patients are encouraged to refrain from vigorous activity, as per postoperative sclerotherapy instructions, for treatment of telangiectasias. Follow-up examinations with DUS are recommended at 2 weeks and 6, 12, and 24 months. Thrombus formation, recanalization, persistent reflux, and postsclerotherapy side effects are evaluated and treated, as necessary.

8.8 Compression Foam Sclerotherapy

The use of foamed sclerosants in the treatment of varicose veins is not new. Worldwide interest in this technique has shown a recent rebirth in foam sclerotherapy. Extensive work has been carried out in the field of foam sclerotherapy by numerous phlebologists over the past six decades, especially in Europe. The following section summarizes a timetable that describes an overview of the major developments of foam sclerotherapy.

8.8.1 The History of Sclerosing Foams

The first recorded use of a foam sclerosant for the treatment of telangiectatic veins was in 1939 by Stuard McAusland. McAusland's technique consisted of shaking a rubber-capped bottle filled with sodium morrhuate, creating a froth. This froth was then transferred into a syringe and injected into the varicose veins. The treated

areas were observed to immediately turn pink, sometimes retract, and instantly disappear [17]. The next recorded treatment was that of Egmont James Orbach in 1944. Orbach took a different approach that did not include the use of foam. Instead, he used two "conventional liquid" techniques, one known as the "full-vein technique" for smaller veins, where the veins were injected while the patient was standing, and the empty-vein technique for larger veins. This technique required the varicose vein segment to first be isolated with two tourniquets. Then, following venipuncture, the leg was raised approximately 45° to 90°. The release of the proximal tourniquet allowed the blood to flow centrally. The purpose of the distal tourniquet was to reduce or even stop the blood supply to the area being treated. This technique lessened the dilution of the sclerosing liquid agent. Through trial and error, Orbach later discovered that reducing the diameter of the vein and clearing it of blood before injecting the sclerosing agent increased the contact between the sclerosing agent and the endothelium. He then injected small amounts of air into the veins to rid them of any remaining blood. Orbach used this air-blocking technique only on small and medium-sized veins [17]. That same year, Robert Rowden Foote's sclerotherapy technique was published in London discussing his rendition of the empty-vein technique. He injected the veins with a soapy froth produced by shaking up 1 cc of ethamoline (ethanolamine oleate) in a 2-cc syringe. Foote believed the "feeder" vein should be treated first. In order to be distinguished as a foam, the gas portion must be greater than 0.52, so Foote's sclerosant was not considered a foam. This technique was geared toward the treatment of smaller and medium-sized veins. Foote's 1+1 air:sclerosant ratio froth was more a liquid than foam and thus could not be used to displace blood in larger veins. Today, ethanolamine oleate is not manufactured in most countries; consequently, this technique is no longer practiced [17].

In 1949, Karl Sigg embraced an air-block technique similar to that created by Orbach five years earlier. However, Sigg's technique was to be used on larger as well as smaller veins. Sigg later combined the air-block technique created by Orbach and the foam technique created by Foote, forming the foam-block technique. He found that the air-block technique was more effective if foam instead of air was injected into the veins because foam has a heightened viscosity and a slower passage rate through the veins than air. Sigg produced his foam by aspirating 1 ml of air into a glass syringe filled with liquid sclerosant with the opening pointed down, thus forming bubbles [17].

One year later, a study conducted by Orbach was published comparing the effectiveness of foam sclerosants with the effectiveness of liquid sclerosants. Orbach used the length of the sclerothrombus, resulting from the injection of a particular sclerosant, to determine the endpoint. He found that the effectiveness of a foam sclerosant formed by agitating the syringe or drug vial was increased 3.5- to 4-fold compared with that of a liquid sclerosant using the same amounts and concentrations of each. Orbach also found that vasospasm was more common and more visible after the use of foam sclerosants because foam can spread throughout venous segments farther than liquids can after vasospasm and are more potent. Orbach's study proved that the foam sclerosants have a greater efficacy than liquid sclerosants [17].

Three years later, in 1953, Arve Ree introduced the new technique of injecting a "pure" foam sclerosant into the venous system to treat telangiectasias and varicose veins. He agitated a solution of detergent in a vial and aspirated the bubbles into the syringe. Ree's technique consisted of injecting 2–7 ml of foam sclerosant, corresponding to an amount of air of up to 6.6 ml. The exact measurements varied depending of the diameter of the veins. Using this technique, Ree successfully treated a series of 50 patients [17].

In 1956, Peter Flückiger advocated the technique "retrograde sclerotherapy." His technique consisted of elevating the leg followed by injection of the foam sclerosant into the saphenous vein proximal to distal so that the sclerosant could reach all insufficient collaterals as well as the saphenous vein via a single injection. Like Foote, Flückiger also used ethanolamine oleate. He found that foam sclerosants yielded much

better results than liquid sclerosants. Flückiger was the first to postulate and discuss the relevant properties of foam. He postulated foam has increased efficacy due to its ability to travel through the venous system further than liquid sclerosants and still maintain its potency. As a result of this increased efficacy, a lesser amount of sclerosant is needed. He determined that the smaller the bubble size, the greater the surface area of sclerosant exposed to the endothelium. He also postulated that the homogeneity of the foam is a very important factor in treatment success. He created a homogenous, fine-bubbled foam by simultaneously aspirating sclerosant and air through a fine-bore needle by submerging only two thirds of the opening of the bevel of the needle into the liquid when aspirating [17].

The following year Heinz Mayer and Hans Brücke introduced their double-piston syringe, a device designed specifically for the production of sclerosing foam. The invention of the double-piston syringe is considered a milestone in the ever-changing foam preparation process [17].

In 1962, Flückiger proposed another technique for the preparation of sclerosing foam. This technique involved pumping air and sclerosant forward and backward between a drug vial and the affixed syringe, forming bubbles and foam. His technique was later amended by Alessandro Frullini who added an adapter, making it possible to use disposable syringes. Then in 2001, Frullini added the option of using sterile air to generate the sclerosant [17].

Flückiger later recommended that following injection of a venous segment, a few minutes should be allowed for the foam to degrade before applying compression to avoid propulsion of foam into the deep venous system; this is still recommended today [17].

In 1963, the first sclerotherapy treatment with Aethoxysklerol (polidocanol) was recorded. This treatment was performed by Peter Lunkenheimer, who used 2 ml of the solution, which was not a known sclerosant at the time [17].

In 1969, Walter Gillesberger introduced the "low-pressure technique" based on generation of a negative pressure in a glass syringe, allowing the air to enter through the space between the syringe piston and the plunger and thus forming bubbles. This technique was modified in 1997 by Alain Monfreux who proposed the idea of capping the glass syringe, yielding an "absolute" negative pressure. Then, in 1998, Symon Sadoun and Jean-Patric Benigni modified Monfreux's technique by making it possible to use plastic syringes instead of glass. Also in 1998, Miguel Santos Gaston adopted and modified Monfreux's technique. After preparing the foam according to Monfreux, Gaston emptied the foam into a glass container and aspirated the foam again. He repeated this several times, producing a finer and drier foam [17].

In 1984, Gerald Hauer introduced his foam preparation technique. He patented his twin-syringe technique, in which he used a twin-syringe set for preparation. The twin syringe consisted of two parallel syringes, one filled with air, and the other filled with sclerosant. Both syringes were simultaneously emptied into a "mixing chamber," under pressure, thus forming a 1+1 ratio foam (sclerosant and air) [17].

Two years later, Michael Grigg introduced a new foam preparation technique (also referred to as the Irvine technique). His technique was based on the concept of creating a turbulent flow between two syringes connected by a plastic infusion tube. The liquid sclerosant and air were pumped back and forth, creating bubbles. The Irvine technique, named after the laboratory where it was developed, was later improved by G. Belcaro and coworkers who added small increments of a heavily foaming detergent to prolong the half-life of the foam. Grigg's technique was a precursor to the Tessari technique and the double-syringe technique, a technical variation of the Tessari technique [17].

In 1995, Juan Cabrera Garrido used high volumes of foam to treat venous malformations and saphenous veins. However, he added a high-speed rotating brush (a modified dental burr) to agitate the foam, and CO_2 as a carrier gas. His objective was to completely fill the venous lumen. Later, however, he reported that the foam could travel from the greater saphenous vein into the deep venous system through the saphenofemoral junction or other connections, thus provoking thrombosis. This tech-

nique does require special safety precautions and is not recommended [17].

In 1999, Javier Garcia Mingo became the first to advocate the use of a device for preparing foam that could be sterilized and used again. This device involved mixing of various gases from a pressure-gas cylinder then passing the mixture through a fine nozzle. This technique is referred to as the "foam medical system." Handling and cleaning the device is complicated and prevents wide usage [17].

In 2000, Lorenzo Tessari introduced the tourbillon technique, or Tessari technique that, along with the technically varied double-syringe system (DSS), is the most commonly used technique to date. Tessari prepared the foam sclerosant using two syringes conjoined by a three-way stopcock. By pumping the liquid sclerosant and air back and forth between the two syringes, bubbles are generated and transformed into foam. The three-way stopcock has an additional advantage of allowing regulation of turbulence, and therefore the size of the bubbles, by turning the stopcock. A narrow passage generates high turbulence and smaller bubbles. This procedure uses 2–2.5 ml of air and 0.5 ml of liquid sclerosant. The concentration of sclerosant varies depending on the diameter of the vessel; generally, 1% Aethoxysklerol for smaller and medium veins and 3% Aethoxysklerol for larger veins. The gas proportion is approximately 0.7–0.83, and the gas bubbles are very fine. The half-life varies with the concentration of the sclerosant and type of syringe (half-life decreases with the presence of silicone in the syringe). Because of the absence of the connecting tube used by Grigg (Irvine technique), much of the silicone is no longer present, resulting in a decrease in the destruction of the foam lamellae [17].

In 2001, Gilles Gachet introduced the "aspiration technique"; this technique was very similar to the 1956 foam preparation technique published by Flückiger [17].

Also in 2001, the DSS, a technical variation of the Tessari technique, was formulated by a group of doctors seeking a quick, sterile, reproducible technique for producing the most stable and fine-bubbled sclerosing foam. Their technique consisted of connecting a 10-ml Injekt syringe and a 10-ml Omnifix syringe (each with a Luer-Lock connection), with a Combidyn adapter (to connect the two syringes) and a 0.2-µm filter for sterilization of air. After aspirating exactly 8 ml of air into the Omnifix syringe via the sterile filter, the filter is removed. Then, 2 ml of polidocanol 3% is drawn into the same syringe. The two syringes are connected to the Combidyn adapter, and pumping movements are first performed against resistance (five times) by applying thumb pressure on the opposite syringe piston until the two components are well mixed. The foam is then rapidly pumped back and forth between the two syringes seven times without resistance (like the Tessari technique), forming a homogenous foam, with a fixed sclerosant:air ratio of 1:5 (=1+4). The half-life of the foam is approximately 150 s, with an initial mean bubble size of 70 µm [17]. Variations in foam stability can occur with divergent syringes, sclerosant concentrations, sclerosant:air ratios, or pumping procedures, making the foam less stable and less viscous.

8.8.2 Compression Foam Sclerotherapy

Compression foam sclerotherapy is not only a powerful device in the treatment of varicose veins, but it is also more effective than the use of the original liquid sclerosant [15]. The first prospective randomized study compared foam sclerotherapy using the DSS with conventional fluid sclerotherapy in 88 patients with long saphenous vein insufficiency. A single injection of 2–2.5 ml of foam or 3% polidocanol solution demonstrated a 2-year occlusion rate of 84% in the foam group versus 40% in the fluid group [17]. Although the results of foam sclerotherapy are clearly seen by the untrained eye, the components of the foam are not simplistic. Presently, there is no "foam sclerotherapy school" because the procedure itself is not sufficiently well established. Various techniques of preparation, treatment regimens, indications, etc., exist without a widely accepted "state of the art." Sclerosing foam is defined as a nonequilibrium dispersion of gas bubbles in a sclerosing solu-

tion where the gas fraction is equal to or greater than 0.52 [liquid-to-gas ratio of 1:5 (1+4)] [15]. The foam is composed of a tensioactive sclerosing agent (usually a detergent sclerosant) and air and is considered more powerful than the original sclerosing solution because of the high concentration of sclerosing agent on the surface of the small air bubbles (micelles). The characterization of the sclerosing foam is dependent upon variables such as the type and concentration of the tensioactive sclerosing agent, type of gas, ratio of liquid to gas, method of preparation, time between processing and use, and bubble size [15, 18]. The characteristics and properties of sclerosing foams account for their action, efficacy, safety, and potency.

8.8.3 Methods for the Preparation of Sclerosing Foam

Using the Monfreux method, the outlet of a glass syringe that contains liquid sclerosing solution is sealed by a rubber or plastic cap. Pulling back the piston generates a negative pressure, which draws air into the syringe through the fine gap between the syringe body and the piston. The end result produces a fluid foam with relatively large bubbles. Monfreux foam properties vary with the concentration of the sclerosant, type of syringe, width of the capillary gap between the body of the syringe and the plunger, and the method and duration of pulling back the piston [17]. Therefore, a defined ratio of gas and sclerosant or defined bubble size cannot be determined with this technique [17]. The DSS, a technical variation of the Tessari technique, utilizes two disposable, latex-free, plastic syringes each with a Luer-Lock connection, a 10-ml Injekt syringe, and a 10-ml Omnifix syringe (with a rubber plunger). The Omnifix syringe is fitted with a 0.2-µm filter for sterilization, and exactly 8 ml of air is drawn into the syringe. The filter is removed and 1 ampoule (2 ml) of polidocanol 3% is drawn into the Omnifix syringe. The two syringes are connected to the Combidyn adapter. Back-and-forth pumping movements are performed five times against resistance by exerting thumb pressure against the piston of one of the syringes. The two components should then be well mixed. The foam is further mixed by quickly pumping back-and-forth seven times without resistance. The sclerosant-to-air ratio is fixed at 1:5 (1+4). The half-life is approximately 150 s, and the initial mean bubble size is 70 µm [17]. The DSS procedure produces a small-bubbled, viscous foam [15] (Figs. 8.8 and 8.9).

The Tessari tourbillon technique utilizes two syringes (various sizes have been described), one containing 0.5 ml of Aethoxysklerol solution and the other containing 2–2.5 ml of air. Various concentrations of sclerosant have been used, but 1% and 3% concentrations are primarily used for large and very large vessels, re-

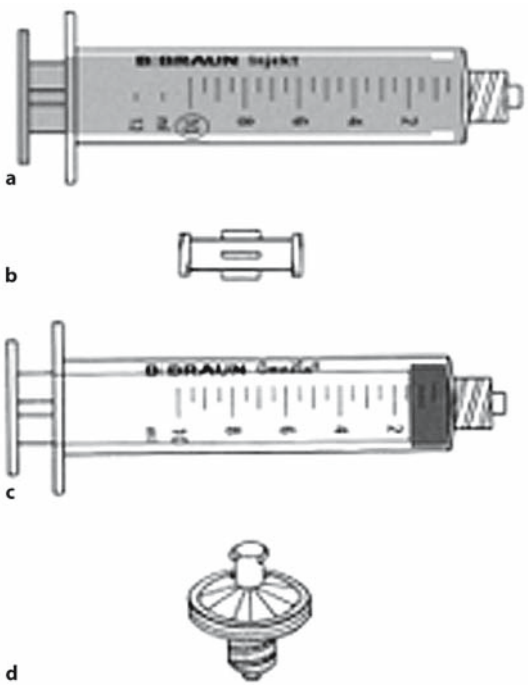


Fig. 8.8a–d. Materials for foam generation. **a** Injekt syringe with Luer-Lock 10 ml for foam generation, **b** Combidyn adapter, f/f, for the safe connection of the syringes during foam generation, **c** Omnifix syringe with Luer-Lock 10 ml, for foam generation, **d** Sterifix 0.2 -µm sterile filter (Personal communication from J-C.G.R. Wollmann M.D.)

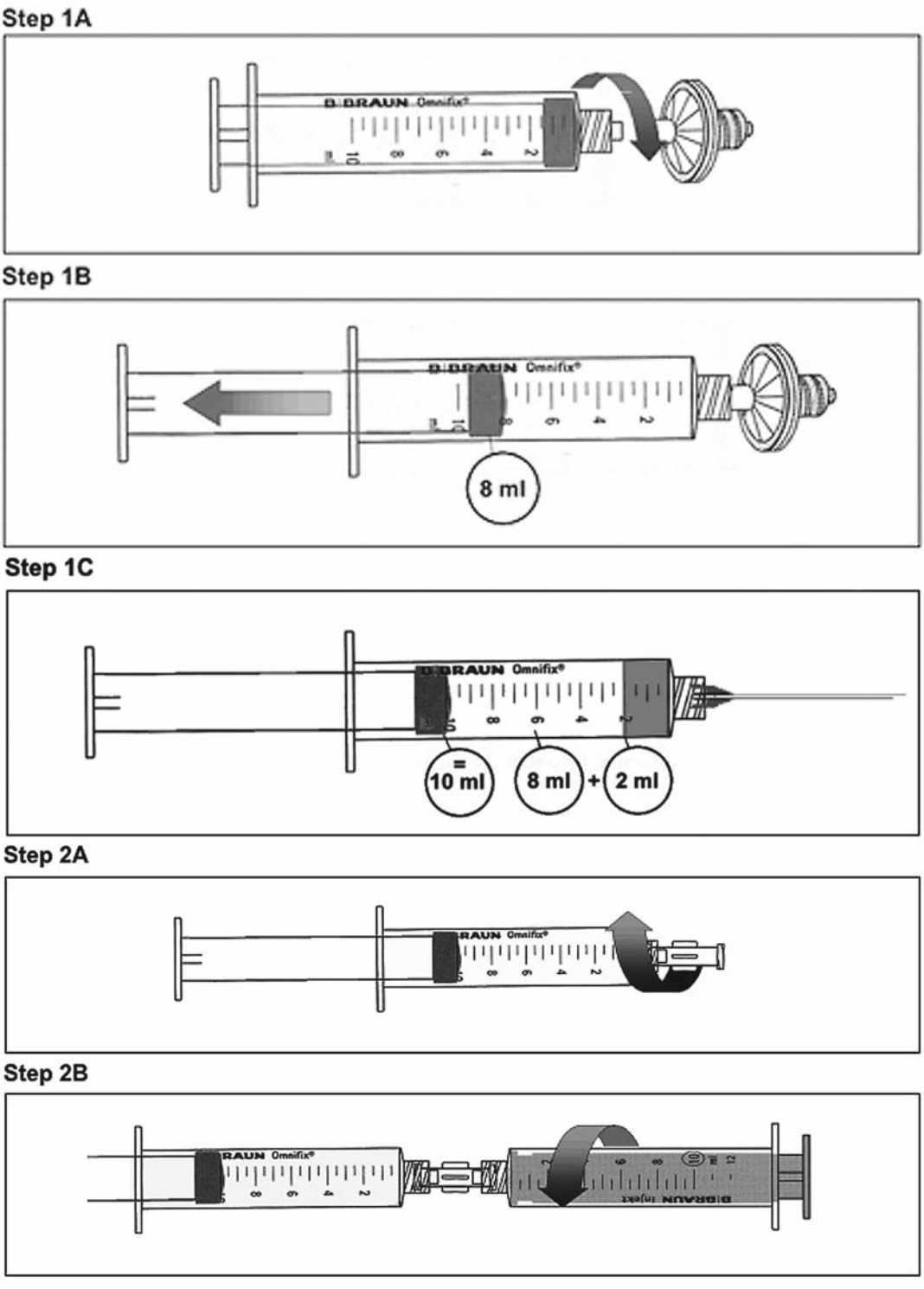
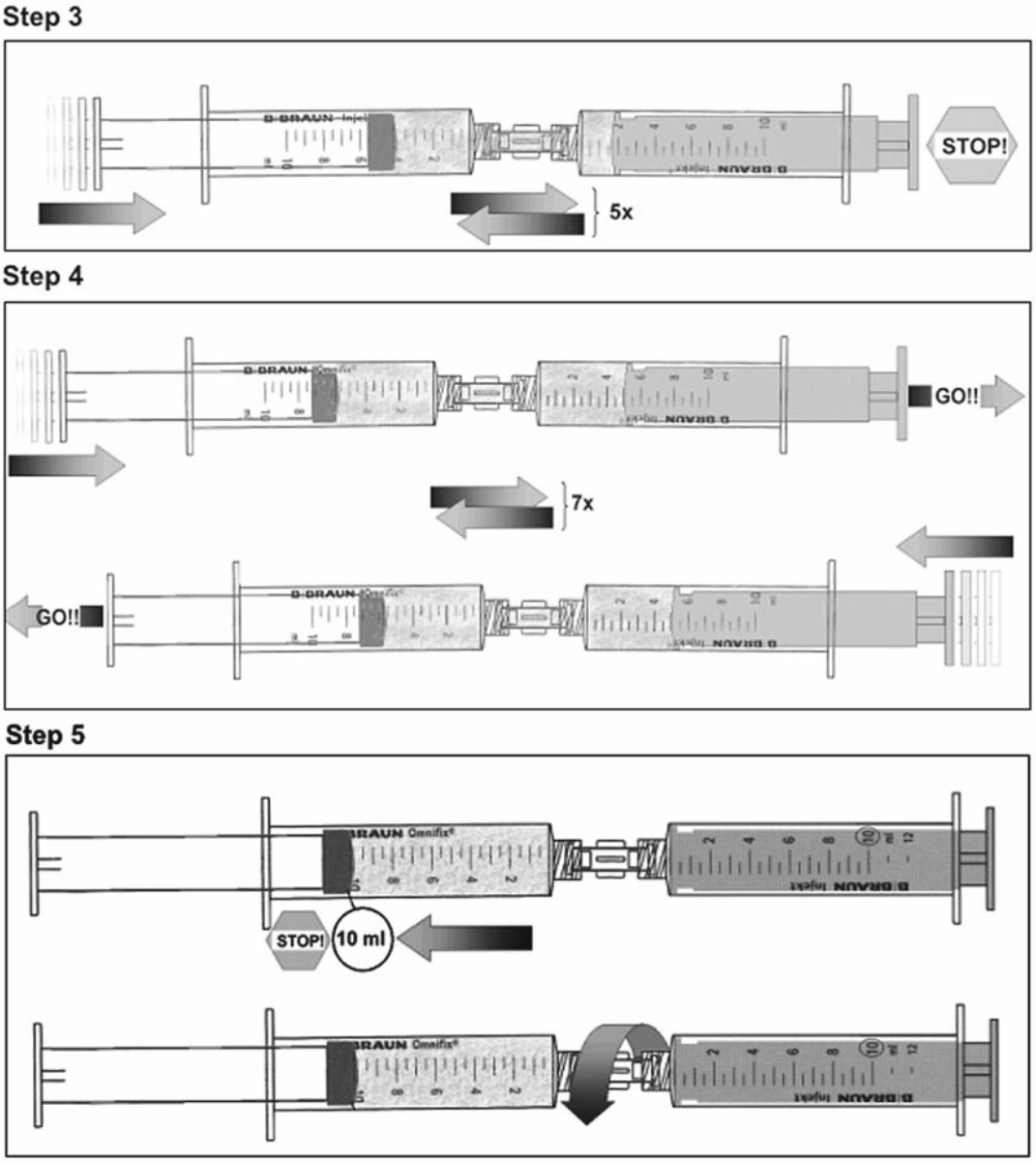

Step 1A
B.BRAUN Omnifix®
Step 1B
B.BRAUN Omnifix®
8 ml
Step 1C
B.BRAUN Omnifix®
=
10 ml
8 ml
+
2 ml
Step 2A
Step 2B

Fig. 8.9.



spectively. The outlets of the two syringes are connected to a three-way stopcock. Pumping the contents of the two syringes back and forth 20 times causes a turbulent flow that generates foam [15]. The three-way stopcock can vary the size of the bubbles by changing the size of the passageway. By turning the cock, a narrow passage can generate high turbulence and, consequently, smaller bubbles. Conversely, a wider passage will generate less turbulence and therefore larger bubbles. Regardless of the concentration of the sclerosant, the gas proportion is approximately 0.7–0.83. Tessari's method yields a very fine, small-bubbled foam, which is fluid if low concentrations of sclerosant are used or viscous if high concentrations are used [15, 18,

Fig. 8.9. a Left: Omnifix syringe; right: (shaded) Injekt syringe. Preparation I: sterile filtration of air. The Sterifix 0.2-µm sterile filter is first screwed onto the three-part, 10-ml Omnifix syringe for sterile filtration of ambient air (*step 1A*), and an exact amount of 8 ml ambient air is drawn up in accordance with the graduation of the syringe barrel (*step 1B*). A hygienically proper procedure is mandatory. Preparation II: drawing up of Aethoxysklerol. Afterward, the Sterifix 0.2-µm sterile filter is removed and 1 ampoule of Aethoxysklerol 3% is drawn up completely (2 ml), as usual, into the same syringe using a sterile disposable cannula (*step 1C*). The inadvertent drawing up of additional sterile air is to be avoided. Preparation III: assembling the dual syringe system. The Combidyn adapter is first firmly connected to the filled Omnifix syringe (*step 2A*) then to the Injekt syringe (*step 2B*) by rotation in order to assemble the dual syringe system. (Personal communication from J-C.G.R. Wollmann M.D.). **b** Left: Omnifix syringe; right: (shaded) Injekt syringe. Foam generation I: mixing phase. The foam generation is performed in two phases: In the first mixing phase, Aethoxysklerol 3% and sterile air are mixed to obtain a dispersion. This is achieved by moving the plunger of the filled Omnifix syringe five times forward and backward with a short, firm, thumb pressure of one hand (*step 3*). The thumb of the other hand holds the plunger of the (shaded) Injekt syringe so that pumping must be done against a resistance, and the Omnifix plunger returns to its starting position by passive pressure. The (shaded) Injekt syringe is held a bit lower. Foam generation II: homogenization phase. The homogenization phase follows immediately: The plunger of the Omnifix syringe is pressed quickly while the plunger of the (shaded) Injekt syringe is not fixed but can move freely so that no resistance is generated at that time. This forward and backward movement is followed by an opposite backward movement by exerting pressure on the plunger of the (shaded) Injekt syringe in the same manner. A total of seven quick forward and backward movements are performed (*step 4*). The plunger of the Omnifix syringe is drawn back to the 10-ml mark to make sure that no excess pressure remains in the double-syringe system (DSS) (*step 5*). The adapter and the (shaded) Injekt syringe are eventually removed and discarded. The mixing phase and the homogenization phase will take a total of 4–5 s for experienced users. A sterile, very fine, homogenous foam is obtained, which remains stable for a couple of minutes. The procedure ensures a high degree of reproducibility if performed correctly. A common injection cannula is then attached or screwed on to the Omnifix syringe, which now contains 10 ml Aethoxysklerol foam for immediate further use. (Personal communication from J-C.G.R. Wollmann M.D.)

19]. The half-life depends on the concentration and the type of syringe used (silicone content).

8.8.4 Indications for Foam Sclerotherapy

According to the 2003 European Consensus Meeting on Foam Sclerotherapy, most participants limit their use of foam sclerotherapy to very large veins and recurrent varicose veins while others limit their use to very small veins. Those who treated small veins were more likely to use the Monfreux method (less viscous foam), and those who treated the larger veins were more likely to use the Tessari method (more viscous foam) [15]. However, regardless of the decided method, it should be noted that veins that are larger in diameter require a more viscous foam and, inversely, veins that are smaller in diameter should be injected with a more liquid foam [15, 18, 19].

8.8.5 Body Position

While there are no strict rules regarding the position of the patient during treatment, there were participants who preferred slight leg elevation. Usually, the patient is in a supine position. Leg elevation is felt to allow the foam to reach more distal parts of the vein. Although most participants agreed that elevating the leg helps in the treatment of larger veins, there was no general consensus with regard to the position of the upper body during treatment.

8.8.6 Recommended Volume of Sclerosing Foam

There is some lack of agreement regarding the volume of foam that should be injected. However, a general consensus regarding recommended volume of foam and caliber of vessel is represented in Table 8.12

Table 8.12. Recommended volume of injection of microfoam sclerosant

Type of vein	Maximum amount per injection site	Maximum amount per session	Technique
C_1 telangiectasia, reticular veins	0.5 ml	4 ml[a] 6–8 ml[a]	Monfreux Tessari
C_2–C_6 varicose veins	N/A	4 ml[a] 6–8 ml[a]	Monfreux Tessari

[a]3 ml or less for short saphenous veins

8.8.7 Injection Variables

Fewer numbers of injections per treatment session are required with compression foam sclerotherapy compared to liquid sclerotherapy [20]. The distance between injection sites can also be increased. One or two injections per session are usually sufficient for large varicose veins [15]. When choosing the optimal location for injecting telangiectatic and reticular veins, most phlebologists found no difference between the injection points for conventional liquid sclerotherapy and foam sclerotherapy. However, the injection points for long saphenous and short saphenous veins with the "open needle" (needle placement without the syringe being connected) and/or "direct puncture" techniques should be at the safest and most accessible location according to the pretreatment duplex examination. The distance to the saphenofemoral junction should be no less than 10 cm [15]. Most sclerotherapists treat varicose veins proximally to distally, starting with the largest veins (with reflux) before treating the smaller veins. After injection of the viscous foam into the vein, the foam column may be directed manually from the point of injection to other areas by repositioning the leg(s) or with manipulation of the duplex probe.

One of the greatest adjuncts for performing successful foam sclerotherapy is the use of DUS during the procedure. The recommended ultrasound frequencies should be between 7.5 and 13 MHz [15].

For the most part, the side effects of compression foam sclerotherapy are similar to those of liquid sclerotherapy, but some occur slightly more frequently with foam sclerotherapy, particularly migraine headaches in those patients with a history of migraine headaches, and transient visual disturbances in patients with patent foramen ovale [21].

Postsclerotherapy compression is highly recommended to avoid thrombus formation. However, it is suggested that a period of approximately 5 min postinjection should elapse before applying manual compression, to avoid propelling foam into the deep venous system. Follow-up treatment regimens for foam sclerotherapy do not appreciably differ from the general recommendations for liquid sclerotherapy.

As previously stated, foam sclerotherapy is a powerful combatant of varicose veins. In the hands of a specialist, foam sclerotherapy is effective and offers relatively few and mild side effects. Although opinions vary in regard to the details of treatment, general consensus has established certain protocols for foam preparation and treatment regimens.

8.9 Complications and Risks

Sclerotherapy is effective and safe in destroying a desired venous segment when performed properly. Sclerotherapy carries a low incidence of complications that are worth mentioning (Tables 8.8, 8.11, and 8.13).

Table 8.13. Allergic reactions from sclerosing agents

Sclerosing agents	Reported reactions
Chromated glycerin (Scleremo)	Hypersensitivity Hematuria (with ureteral colic) Ocular manifestations Hypertension Visual disturbances
Ethanolamine oleate (Ethamolin)	Pleural effusion (infiltration) Anaphylactic shock Local inflammatory Coagulation in vitro Renal failure Hemolytic reaction Constitutional symptoms (with aching in the loins and passage of red-brown urine) Pyrexia and substernal chest pain
Hypertonic glucose/saline (Sclerodex)	Allergic reaction to the propylene glycol component in susceptible patients
Hypertonic saline	Hypertension Hematuria (painless)
Polidocanol (Aethoxysclerol)	Anaphylactic shock (very rare) Urticaria Dyspnea Cardiac toxicity
Polyiodinated iodine (Sclerodine, Variglobin)	Tissue necrosis Cutaneous reactions Varicophlebitis Bronchomucosal lesions
Sodium morrhuate	Erythema (with pruritus) Urticaria Gastrointestinal disturbances (abdominal pain and diarrhea) Anaphylaxis Edema Dysrhythmia–cardiac

8.9.1 Postsclerotherapy Hyperpigmentation

The incidence of pigmentation postsclerotherapy appears to be related to multiple factors, including (1) type and concentration of sclerosing solution, (2) technique, (3) gravitational and other intravascular pressures, (4) tendency toward cutaneous pigmentation, and (5) treatment postsclerotherapy. Three histologic studies on postsclerotherapy pigmentation demonstrated this complication to be caused by hemosiderin only [2]. The incidence of hyperpig-

mentation following sclerotherapy has been reported to occur at a rate of 0.3–10% and up to 30% [2]. Postsclerotherapy hyperpigmentation usually occurs 6–12 weeks after treatment [2]. The general rule is slow regression of the hyperpigmentation with a 1% incidence of pigmentation persisting after 1 year [2]. Georgiev recommends a single "trial" sclerotherapy session with chromated glycerin to select patients at risk of developing postsclerotherapy hyperpigmentation [22]. Those patients who develop hyperpigmentation from intravascular chromated glycerin should be treated with a milder sclerosant, he goes on to say. Duffy and Sadick have not found the addition of 100 U/ml of heparin to sodium tetradecyl sulfate sclerosant (which has the highest incidence of hyperpigmentation) to decrease the incidence of postsclerotherapy hyperpigmentation and may, in fact, promote angiogenesis [2]. Marley reported a decrease in postsclerotherapy hyperpigmentation when injecting veins proximally to distally [2]. Goldman et al. report a decrease in the incidence of postsclerotherapy pigmentation from 40.5% to 28.5% in patients wearing class II (30–40 mmHg) graduated compression stockings [1]. Chatard and Goldman both agree that the incidence of postsclerotherapy hyperpigmentation is not more pronounced in persons of color [2]. Treatment of postsclerotherapy pigmentation is often unsuccessful. Hydroquinone bleaching agents are ineffective in reducing this form of hemosiderin-deposited pigment. I have utilized the Q-switch Nd:YAG laser in selected patients with some improvement.

8.9.2 Edema

Edema is most common among patients with treated telangiectasias and varicose veins below the ankles, due to gravitational pressure and diminished perivascular fascia in the area [2]. The extent of edema is also related to the strength of the sclerosant and release of histamine and other mediators that increase endothelial permeability. Edema also occurs when compression is not applied in a graduated manner [2, 6]. Recommendations for prevention of edema include limiting the quantity of sclerosant injected to 1 ml per ankle and application of a class II (30–40 mmHg) graduated stocking postinjection to be worn for at least 3 days after the treatment.

8.9.3 Telangiectatic Matting

The new appearance of a fine web of erythematous telangiectasias occurring after sclerotherapy or surgical ligation of varicose or telangiectatic veins is referred to as distal angioplasia or, more commonly, telangiectatic matting (TM) [2]. The reported incidence ranges from 5% to 75%, with an overwhelming female predominance. The etiology of matting is unknown but is felt to be related to either neoangiogenesis (a normal reparative process after "wounding" of injection), or dilation of existing subclinical blood vessels by promoting collateral flow through arteriovenous anastomoses [11]. Heparin has been demonstrated to produce angiogenesis in vivo [2]. Ouvry, Davy, and Mantse first described postsclerosis TM and have noticed a decreased incidence of matting when the pressure of injection is minimized and the sclerosant is dispersed not more that 1 cm beyond each injection site [2]. Davis and Duffy reported their findings identifying risk factors among 160 patients who developed TM. Significantly more patients with matting were overweight, on hormone therapy during treatment, had a family history of spider veins, and a longer duration of their spider veins prior to treatment. Additionally, the matting group noted the onset of their veins after excess hormonal states [23]. Age and excessive standing do not appear to play a role in the development of TM [2]. Therefore, any technique that may limit this occurrence should be employed, such as limiting the injection blanch to 1–2 cm, discontinuation of estrogen preparations prior to and during treatment, and avoidance of heparin in the sclerosant. Fortunately, TM usually resolves over a 3- to 12-month period. For the rare permanent TM, use of the newer vascular lasers may provide resolution of this condition.

8.9.4 Localized Urticaria

Localized urticaria, or hives, is likely to occur after sclerotherapy with any of the sclerosing solutions. The intensity level of the urticaria is dependent upon the concentration of the solutions used. The severity of the urticaria and the subsequent itching may be decreased if topical steroids are applied to the area immediately following the injection.

8.9.5 Tape Compression Blister Formation

This relatively uncommon cutaneous condition may occur when a tape dressing is applied to an area of tissue movement, such as the posterior calf, medial thigh, and popliteal fossae. The blister usually appears as a flaccid fluid-filled sack overlying normal-appearing skin. While these blisters can occur in response to the use of any tape, they occur more often when a 3M Microfoam tape is used. The tension with which this tape is typically applied increases the likelihood of blistering. Other variables that instigate blistering are hot weather conditions and thin and fragile skin.

It is important to take time and explain this reaction to the patient and to distinguish it from sclerotherapy-induced cutaneous necrosis or cutaneous infection. Early cutaneous necrosis may appear as a superficial blister. However, the underlying and adjacent tissue is usually indurated and erythematous. Bullous impetigo can have a similar appearance, but the underlying skin is usually warm and erythematous. The patient might also incorrectly assume that the blisters are an allergic reaction to the sclerosant. Fortunately, adhesive tape blisters resolve without any adverse sequelae within 1–2 weeks. The use of an occlusive hydroactive dressing, such as Duoderm, can aid in healing, prevent infection, and alleviate pain.

8.9.6 Tape-Induced Folliculitis

Occlusion of any hairy area can produce folliculitis. Men who are being treated for varicose veins are more prone to tape compression folliculitis. Tape dressings placed over foam or cotton-ball pads or under a graduated compression garment can produce follicular inflammation or infection. Folliculitis is also more likely to occur when sclerotherapy is performed during the summer months, as a result of increased activity and perspiration. Treatment involves topical treatment with an antibiotic gel or solution, such as 2% erythromycin or clindamycin phosphate.

8.9.7 Vessel Recurrence

Recurrence of treated vessels has been estimated to occur at a rate of 20% to nearly 100% of treated leg telangiectasias at the 5-year follow-up [2]. The larger the postsclerosis intravascular thrombosis, the greater is the likelihood of recanalization of thrombus [4, 14]. Therefore, the most important factor in preventing recurrence is limiting intravascular thrombosis. Compression decreases the extent of thrombus formation thereby decreasing the risk for recanalization. Three weeks of continuous compression with class II (30–40 mmHg) graduated compression stockings gives the best results, but even 3 days of compression is beneficial [12]. Additionally, the importance of draining postsclerotherapy thrombi has been emphasized by Sigg, Pratt, and Hobbs [2]. Recanalization through a sclerosed telangiectasia is not common; histologic studies have demonstrated only fibrosis [2].

8.9.8 Vasovagal Reactions

Vasovagal reflex is a common adverse sequelae of any surgical or invasive procedure. Usual symptoms include lightheadedness, nausea, and sweating. Vasovagal reactions are typically preceded by a painful injection but may occur when the patient sees the needle or smells the

sclerosing solution or alcohol skin prep or is injected while standing. Patients with a history of asthma or coronary artery disease are more susceptible to more serious stress-induced problems. A good medical history preoperatively can prepare the phlebologist for this potential reaction.

8.9.9 Cutaneous Necrosis

The incidence of cutaneous necrosis does not discriminate between sclerosing agents. Necrosis can result from extravasation of a sclerosing solution into the perivascular tissue, injection into a dermal arteriole or an arteriole feeding into a telangiectatic or varicose vein, a reactive vasospasm of the vessel, injection of a sclerosant in higher concentrations than required for the treatment vessel diameter or excessive cutaneous pressure created by compression techniques [2, 3, 24]. Due to the degree of possible human error, the injection technique is an important, but not foolproof, factor in avoiding this complication, even under optimal circumstances. Polidocanol appears to be the least toxic sclerosant to subcutaneous tissue (Tables 8.8 and 8.11). However, in sufficient concentrations, it has been reported to cause cutaneous necrosis (concentrations greater than 1%) [2, 25, 26]. Excessive compression of the skin overlying the treated vein may produce tissue anoxia with the development of localized cutaneous ulceration and may ultimately produce tissue ischemia. Therefore, it is recommended that patients not wear a graduated compression stocking of over 30–40 mmHg for long periods of time when the patient is recumbent [2]. Whatever the cause of the ulceration, institution of treatment at the time of occurrence is optimum. Fortunately, most ulcers that occur are small (24-mm diameter), and primary healing usually leaves an acceptable scar. For larger ulcers, hydrocolloid or saline wet-to-dry dressings result in a decreased healing time after proper wound debridement. Excision and closure of these lesions is also recommended, as this affords the patient the fastest healing and an acceptable scar.

8.9.10 Allergic Reactions

Because of the possibility of angioedema or bronchospasm, each patient with evidence of an allergic reaction should be examined for stridor and wheezing by auscultating over the neck and chest while the patient breathes normally. Minor reactions like urticaria can be treated with oral antihistamines; however, if stridor is present, an intramuscular injection of diphenhydramine and intravenous corticosteroids should be administered. Bronchospasm is estimated to occur postsclerotherapy in 0.001% of patients [2] and responds to inhaled bronchodilators or IV aminophylline. Four types of potentially serious systemic reactions specific to the type of sclerosing agent used have been noted: anaphylaxis, pulmonary toxicity, cardiac toxicity, and renal toxicity [2]. Anaphylaxis is usually IgE mediated, mast-cell derived, and occurs within minutes of exposure to the offending agent. Clinical manifestations include airway edema, bronchospasm, and vascular collapse. Since the risk of anaphylaxis increases with repeated exposures to the antigen, the phlebologist should always be prepared for this reaction in every patient. Initial signs and symptoms may be subtle and can include anxiety, itching, sneezing, coughing, urticaria and angioedema, wheezing, and vomiting, progressing to vascular collapse and cardiovascular failure. Recommended treatment at the onset of symptoms includes epinephrine 1:1,000 subcutaneously injected (0.2–0.5 ml) repeated three to four times at 5–15-min intervals. Emergency medical services should be immediately sought as well. Rarely has anaphylaxis resulted in fatality. There have been no reports of pleural effusion with injection into varicose veins of the legs.

8.9.11 Superficial Thrombophlebitis

Before the advent of modern-day sclerotherapy and the use of postsclerotherapy graduated compression, both superficial and deep thrombophlebitis occurred in a significant number of sclerotherapy patients [2, 11, 12]. Superficial

thrombophlebitis appears 1–4 weeks following sclerotherapy as a tender erythematous induration of the injected vein. Even when appropriate compression is used, thrombosis and perivascular inflammation may occur. Ascending phlebitis in the long saphenous vein or its tributaries can develop at the upper edge of the compression stocking. Creating a gradual transition of pressure from compressed to noncompressed vein(s) may mitigate this development. In addition to appropriate compression, drainage of thrombi after liquefaction of the clot has occurred (in approximately 2 weeks) will hasten resolution. If untreated, the inflammation and clot may spread to perforating veins and the deep venous system, leading to possible valvular damage and pulmonary embolic phenomena. Frequent ambulation and aspirin or other nonsteroidal anti-inflammatory agents may also be helpful.

8.9.12 Arterial Injection

Intraarterial injection of a sclerosant is a very rare complication. The most commonly reported location for intraarterial injection is into the posterior tibial artery in the area of the posterior or medial malleolar regions of the ankle [2]. Immediate pain, cutaneous blanching in an arterial pattern, loss of pulse, and progressive cyanosis usually occur.

Another area where arterial and venous circulation are in close proximity is at the junction of the femoral and long saphenous veins [2, 3]. The external pudendal artery bifurcates and may surround the long saphenous vein just after its connection with the femoral vein. Because of anatomical variations of these collateral arteries, duplex scanning is important before injection of sclerosants in this area.

8.9.13 Pulmonary Embolism/ Deep Venous Thrombosis

The occurrence of pulmonary emboli after sclerotherapy is very rare. Deep vein thrombosis and embolic episodes usually occur 4–28 days after sclerotherapy, and most cases have been associated with injection of large volumes of sclerosant (12 ml) at a single site. With the use of duplex-guided foam sclerotherapy, the amount and concentration of sclerosing solution is reduced [15, 18]. The sclerosing foam displaces the intravascular blood with very little dilution of the sclerosant, and the active surface of the sclerosant is increased as a result of the preparation of the foam [15]. Sclerosing foam is highly echogenic, and safe intravascular injections can be controlled by an experienced phlebotomist using duplex-guided foam sclerotherapy technique. Other techniques that will minimize damage to the deep venous system include leg elevation during the treatment of large varicose veins (impedes penetration into the deep venous system), postsclerotherapy compression of the treated vein with local compression, and a class II graduated compression stocking followed by immediate ambulation and frequent ambulation thereafter to dilute the sclerosant [6].

8.9.14 Nerve Damage

The saphenous and sural nerves may be injected during sclerotherapy due to their close proximity to the long and short saphenous veins. Severe pain, anesthesia, and permanent nerve dysfunction can occur. Paraesthesias, as a result of perivascular inflammation of a sclerosed vein that is adjacent to superficial nerve(s), can also occur. This complication may take 3–6 months to resolve and may be helped with nonsteroidal anti-inflammatory medications and high-potency topical corticosteroids.

8.10 Conclusion

The permanent eradication of varicose veins with sclerotherapy continues to evolve as a result of the development of new, and improvement of old techniques. Advantages of sclerotherapy include the lack of anesthesia and avoidance of hospital stay, low morbidity rate, and no “down time” or loss of work. Standardization of treatment guidelines for the practice of sclerotherapy, however, remains elusive. Sev-

Table 8.14. Sclerosing solutions distributors

Sclerosing solutions	Brand names	Distributors
Chromated glycerin	Scleremo	Laboratories E. Bouteille 7, Rue des Belges 87100 Limoges, France Omega Montreal, QC, Canada H3M3A2
Ethanolamine oleate	Ethamolin	Block Drug Company 1 New England Avenue Piscataway, NJ 08855, USA
Hypertonic glucose/saline	Sclerodex	Omega Montreal, QC, Canada H3M3A2
Hypertonic saline 23.4%	N/A	American Regent Laboratories, Inc. Shirley, NY 11967, USA Henry Schein 135 Duryea Road Melville, NY 11747, USA Invenex Gibcol Inevex Division The Dexter Corporation Chagrin Falls, OH 44022, USA Omega Montreal, QC, Canada H3M3A2
Polidocanol	Aethoxysklerol	Kreussler & Co. GmbH Chemische Fabrik Rheingaustr. 87 65203 Wiesbaden, Germany Globopharm AQ P.O. Box 1187 8700 Kusnacht, Switzerland Laboratoiries Pharmaceutiques DEXO, S.A. 31 Rue D'Arras 92000 Nanterre, France
Polyiodinated iodine	Sclerodine, Variglobin	Sclerodine from: Omega Montreal, QC, Canada H3M3A2 Variglobin from: Globopharm AQ P.O. Box 1187 8700 Kusnacht, Switzerland
Sodium morrhuate	N/A	American Regent Laboratories, Inc. 219 Country Road Tenafly, NJ 07670, USA Palisades Pharmaceuticals, Inc. 219 Country Road Tenafly, NJ 07670, USA
Sodium tetradecyl sulfate	N/A	Eklins-Sinn, Inc. (A subsidiary of A.H. Robins Company) 2 Esterbrook Lane P.O. Box 5483 Cherry Hill, NJ 08034, USAS

eral sclerosing solutions are currently available for the treatment of varicose and telangiectatic vessels (Table 8.14). The "ideal" sclerosant, concentrations, or appropriate volumes have yet to be determined. Compression sclerotherapy for the treatment of varicose veins has been widely used for many years. However, there is still no uniform agreement regarding duration of compression, type of compression, caliber of vessel requiring compression and type or use of adjunctive compression padding. A great deal of variable data exists regarding the duration and effectiveness of compression. Should patients avoid hot showers or baths during the period of postsclerotherapy compression in order to eliminate unwanted vasodilatation? Likewise, parameters for pre- and post-treatment protocols, retreatment and follow-up intervals are presently not established. These are questions that both the practitioner and patient need to have answered.

Introduction of the use of diagnostic tests, such as continuous-wave Doppler ultrasound, DUS, and color-duplex sonography as aids in the treatment of incompetent varicose and perforating veins, have certainly allowed for improvement in diagnosis, treatment technique, outcome, and reduction in postsclerotherapy complications. At the moment, uniform guidelines for the use of diagnostic tests pretreatment, during treatment, and postsclerotherapy have not been established.

Foam sclerotherapy represents a major therapeutic advancement in the treatment of varicose veins, but there is no "foam sclerotherapy school." Standardized procedures and instrumentation for transforming sclerosing solutions into sclerosing foam, as well as the type and concentration of sclerosing agents used, are currently lacking. The types of vessels treated with foam sclerotherapy range from spider veins only to exclusively large, incompetent varicose veins [15]. The benefit of foam sclerotherapy for smaller vessels and spider veins needs to be further demonstrated in randomized controlled studies.

Standard guidelines for treatment of complications such as perivenous extravasation and ulcer formation, postsclerosis pigmentation and TM (telangiectatic matting) currently do not exist. There is no controlled data regarding sclerotherapy when performed on patients taking certain medications, in particular, anticoagulants and Antabuse. This, too, should be studied. Clearly, attempts to unify medical opinion and to standardize the practice of sclerotherapy are worthy of ongoing consideration, research and discussion.

References

1. Goldman MP, Duffy DM, Sadick MD, Weiss RA (1996) Guidelines of care for sclerotherapy treatment of varicose and telangiectatic leg veins. J Am Acad Dermatol 34:523–528
2. Goldman MP (1991) Sclerotherapy: Treatment of varicose and telangiectatic leg veins. Mosby, St. Louis, pp 56
3. Green D (1998) Sclerotherapy for permanent eradication of varicose veins: theoretical and practical considerations. J Am Acad Dermatol 38:461–475
4. Goldman MP, Weiss R, Bergen J (1994) Diagnosis and treatment of varicose veins: a review. J Am Acad Dermatol 31:393–413
5. Fronek HR (1989) Noninvasive examination of the venous system in the leg: presclerotherapy evaluation. J Dermatol Surg Oncol 15:170–173
6. Rabe E et al (2004) Guidelines for sclerotherapy of varicose veins. Dermatol Surg 30:686–693
7. Kanter A (1998) Clinical determinants of ultrasound-guided sclerotherapy outcome part I: The effects of age, gender, and vein size. Dermatol Surg 24:131–135
8. Kanter A (1998) Clinical determinants of ultrasound-guided sclerotherapy part II: In search of the ideal injected volume. Dermatol Surg 24:136–140
9. Thibault PK (1995) Duplex examination. Dermatol Surg 21:77–82
10. Goldman MP, Bennett RG (1987) Treatment of telangiectasias: A review. J Am Acad Dermatol 17:167–182
11. Goldman MP et al (1990) Compression in the treatment of leg telangiectasia: a preliminary report. J Dermatol Surg Oncol 16:322–325
12. Weiss RA, Sadick NS, Goldman MP, Weiss MA (1999) Postsclerotherapy compression: controlled comparative study of duration of compression and its effect of clinical outcome. Dermatol Surg 25:105–108
13. Scurr JH, Coleridge-Smith P, Cutting P (1985) Varicose Veins: optimum compression following sclerotherapy. Ann R Coll Surg Engl 67(2):109–111
14. Tezelaar DJ, Neumann HAM, De Roos KP (1999) Long cotton wool rolls as compression enhancers in macrosclerotherapy for varicose veins. Dermatol Surg 25:38–40
15. Breu FX, Guggenbichler S (2004) European consensus meeting of foam sclerotherapy. Dermatol Surg 30:709–717

16. Goldman MP et al (1996) Guidelines of care for sclerotherapy treatment of telangiectatic leg veins. J Am Acad Dermatol 34:523–8
17. Wollmann J-CGR (2004) The history of sclerosing foams. Dermatol Surg 30:694–703
18. Frullini A, Cavezzi A (2002) Sclerosing foam in the treatment of varicose veins and telangiectases: history and analysis of safety and complications. Dermatol Surg 28:11–15
19. Tessari L, Cavezzi A, Frullini A (2001) Preliminary experience with a new sclerosing foam in the treatment of varicose veins. Dermatol Surg 27:58–60
20. Yamaki T, Nozaki M, Iwasaka S (2004) Comparative study of duplex-guided foam sclerotherapy and duplex-guided liquid sclerotherapy for the treatment of superficial venous insufficiency. Dermatol Surg 30:718–722
21. Kern P et al (2004) Single-blind randomized study comparing chromated glycerin, polidocanol solution and polidocanol foam for treatment of telangiectatic leg veins. Dermatol Surg 30:367–372
22. Georgiev M (1993) Postsclerotherapy hyperpigmentations. J Dermatol Surg Oncol 19:649–652
23. Davis LT, Duffy DM (1990) Determination of incidence and risk factors for postsclerotherapy telangiectatic matting of the lower extremity: A retrospective analysis. J Dermatol Surg Oncol 16:327–330
24. Bergon JJ, Weiss RA, Goldman MP (2000) Extensive tissue necrosis following high concentration sclerotherapy for varicose veins. Dermatol Surg 26:535–542
25. Sadick NS (1994) Hyperosmolar versus detergent sclerosing agents in sclerotherapy. J Dermatol Surg Oncol 20:313–316
26. Sadick NS (1990) Treatment of varicose and telangiectatic leg veins with hypertonic saline: a comparative study of heparin and saline. J Dermatol Surg Oncol 16:24–28