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The anatomical variables of the sapheno-popliteal junction Visualization by radiological and echographic examinations

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SUMMARY

Increasing interest on the short saphenous vein has been induced by its employment as autologus graft in arterial surgery and for being held responsible for the onset and development of varicose veins of the lower limbs and postoperative recurrence. These two clinical conditions require a more precise assessment of the short saphenous anatomy and its variables previously described in literature. A verify of the anatomical variations of the sapheno-popliteal junction and of the short saphenous outlet in 528 not randomized limbs was performed in separate groups by the following methods: High Resolution Echography, preoperative ascending Phlebography, preoperative Digital Phlebography, intraoperative Selective Phlebography.

A high number of anatomical variations was found (29.8%) and the conclusion was that modest differences between published data by other Authors and the results of this study were found.

The ideal diagnostic approach for these anatomical variations is the intraoperative Selective Phlebography in cases systematically selected by preoperative High Resolution Echography.

INTRODUCTION

Special attention has been recently focused on the short saphenous vein (SSV) for the following reasons: it can be used as autologous graft in arterial by-pass surgery (Szilagy *et al.* 1989, Thiene *et al.*, 1980); it is often held responsible for the onset and development of varicose conditions of the lower limbs and for their recurrence after surgical treatment (Corcos *et al.* 1985-1986, Davy *et al.* 1986, May

1978, Marques 1975-1986, Popov 1985, Rettori 1985, Sheppard 1986, Van Der Stricht 1985).

Clinical experience demonstrated that, since practising a systematic preoperative investigation on the hemodynamic and anatomic feature of the SSV before surgery for varicose veins of the lower limbs (VVLL), has led to the incidence of recurrence being significantly reduced (2,5%) (Corcos *et al.* 1986, Frileux *et al.* 1985, Hobbs 1980-1986, Jantet 1985, Marques 1975-1986).

A histopathological research of "apparently normal" segments of the SSV removed from patients with VVLL of the sural region and in which clinical tests and examinations have shown no anatomical or hemodynamic damage of the SSV have shown evidence of parietal phlebosclerosis in all the segments examined (Corcos *et al.*, 1985-1986).

Marques (1989) has pointed out that the anatomical location of the SSV and the existence of a satellite nerve and artery (sural artery and nerve) make it overlapping to a major perforating vein of the leg.

The conclusion from these considerations is that the SSV must be taken into higher consideration during radical surgery for VVLL (Corcos *et al.* 1986, Frileux *et al.* 1985, Haeger 1962, Hobbs 1980-1986, Jantet 1985, Marques 1986, May 1978, Ouvry *et al.* 1986, Rettori 1985, Rosati 1977, Sheppard 1986, Van Der Stricht 1985) and its savaging is thus not justified for possible grafting in vascular surgery (Szilagy *et al.* 1989, Thiene *et al.*, 1980).

The next problem considered is that of how to perform a correct and complete posterior saphenectomy, given the not infrequent cases of anatomical variations in the outflow of the SSV. Publications on the subject give this confluence in a number of cases varying between the 57.3% and 84.6%. In other cases the SSV joins the femorals system, the femoral-popliteal vein, the long saphenous or the posterotibials. (Hobbs 1980-1986, Haeger 1962, Kosinski 1926, May 1978, Ouvry *et al.* 1986, Sheppard 1986). In these cases the SSV outlet is not to be named "saphenopopliteal junction" (SPJ). (*Table 1*).

The variation in the above percentages is probably due to different interpretations of the anatomical data coming from various methods of research by the different writers.

TABLE 1 — *Anatomical variables of the SPJ - Published data.*

Author	Year	Method	Termination of the SSV		
			Normal %	High %	Low %
Kosinski	1926	Anat.	57,3	33	9.7
Haeger	1962	Surg.	60	32	8
May	1978	X-R	84,6	13,8	1.4
Hobbs	1980	X-R	60	30	10
Sheppard	1986	X-R	60	30	10

This large number of anatomical variations and anatomical topographical possibilities in the termination of the SSV makes surgical exploration undesirable: it would be long, investigative and traumatizing.

Pre-operative tests to attempt to identify the actual termination of the SSV have been made using the Doppler technique. This method is normally used to study alterations in the flow but can also be used to follow the veins and their terminations in the deep system. Although normal termination in the popliteal fossa (SPJ) can be safely identified, evidence as to the termination of the SSV elsewhere seems to be less reliable.

High Resolution Echography gives reliable informations by providing a visual image of the vessels in question. As this test is not invasive it may be performed easily and, if necessary, repeated to check the accuracy of the image (Antignani *et al.* 1993, Bergan *et al.* 1993, Fronek 1989, Peruzzi *et al.* 1991).

Traditional phlebography is nowadays much improved and may be used more readily, thanks to non-ionic radio-opaque agents (lohexol, lopamiro). The preoperative investigation of the SSV termination may also be carried out in cases requiring phlebographic tests for other reasons (Gullmo 1972, Hobbs 1980-1985, Jantet 1985).

Digital phlebography, used in a limited number of cases (Fonda *et al.* 1986) can be easily performed and presents no risks. Its use however is limited by the high cost and limited extent of the imaging.

Phlebography, if performed intraoperatively, can be somewhat more selective and indicative, requiring minimum doses of radio-opaque agent and taking only a few minutes to perform. This method has been valued as the "gold standard in surgery" (Frileux 1985, Hobbs 1980, May 1978, Sheppard 1986).

Table 1 showes the results obtained by Authors with anatomical, surgical and radiological investigations.

The purpose of this study is to verify the frequency of a normal SPJ, the sites and frequency of the anatomical variations of the SSV outler and clarify the indications to the different diagnostic approaches.

MATERIALS AND METHODS

In 528 not randomized limbs, affected with various kind and degree of venous disease of the lower limbs, the location and outlet of the SSV was studied and visualized during patients diagnostic procedure: 250 by Hig resolution Echography, 164 by preoperative Phlebography, 14 by Digital Plebography and 100 by intraoperative Phlebography.

Echographic investigations were performed during a Duplex hemodynamical study of the lower limb with the use of 7,5 - 13,5 MHz probes with patient in standing position and the knee mildly bended. Preoperative ascending Phlebographies were performed with patient lying on a table 60° inclined.

The injection of 40 - 80 non ionic contrast medium was performed via the dorsal vein of the foot and limbs were studied in the anterio-posterior and lateral position. No rubber loop was applied during the superficial venous system visualization. Phlebograms were performed under video monitoring control.

Digital Phlebographies were performed with the same method using minimum dosage of contrast medium and with the image subtraction technique.

100 intraoperative selective phlebographic examinations of the SSV were performed with the following method.

The SSV is exposed via an incision at the external malleolus or at the upper and medial third of the leg, divided and cannulated.

Phlebography is performed at a later stage in the operation following disconnection of the sapheno-femoral junction, the introduction of the intraluminal phleboextractor for stripping of the long saphenous vein, when necessary, much of the varicectomies and, in severe cases, the disconnection of the communicating veins in the leg.

Just before the injection, the common femoral vein is blocked off by means of clamp to control the dispersion of radio-opaque agent. The limb is rotated slightly to the lateral side. A thin catheter is inserted into the stump of SSV and 20 ml of lopamiro 300 in a 50% dilution with saline solution is injected and the radiogram taken immediately. When the stump of the SSV is in the sural region a single radiographic plate of 30×40 cm is used and positioned between the lower point of the popliteal space and the gluteal fold. In the case of a malleolar stump a second plate of the same size is placed distally, in contact with the first one, and the test is performed taking two radiograms. Following phlebography the clamp is removed from the femoral vein and sodium heparine (1000 I.U.) or simply saline solution (20 ml) used to wash the area.

The test is simple to perform, does not require specialized equipment (portable radiological apparatus only) and has not caused the onset of complications. During the echographic examinations the single details of the deep SSV outlets which were out of the popliteal region were not easily detectable. For this reason the cases were divided into three groups according with previous researches published (Haeger 1962, Kosinski 1926, May 1978): the SSV outlet located in the popliteal vein and in the popliteal region was named "normal termination»; outlet in the thigh into the superficial femoral vein was named "high termination" and the outlets detected in the posterior tibials in correspondence of the middle calf perforator were named "low termination" (*Tab. 2*).

More detailed information were obtained by the radiological examinations but only by Selective intraoperative Phlebography it was possible to detect all the SSV outlets in the deep or superficial veins of the lower limbs examined: popliteal, femoro-popliteal, superficial femoral/s, long saphenous, posterior tibial/s. For this reason intraoperative findings were divided into 8 subgroups (*Tab. 3*).

Different methods were employed in separate causistries and in different periods and only in a low number of clinical cases both radiological and echographic

TABLE 2 — *Anatomical variables of the SPJ - 528 Examin.*

Number	Method	Termination of the SSV					
		Normal		High		Low	
		N.	%	N.	%	N.	%
250	Echogr.	210	*84*	30	*12*	10	*4*
164	Preop. X-R	100	*60,9*	38	*23,1*	26	*15,8*
14	Dig. X-R	9	*64,2*	3	*21,4*	2	*14,2*
100	Intraop. X-R	51	*51*	26	*26*	23	*23*
528	Total	370	*70*	97	*18,3*	61	*11,5*

TABLE 3 — *Anatomical variables of the SPJ - 100 intraoperative X-R observations*

Termination	N. = %	Subgr.	Outlet of SSV in vein	N. = %
Normal*	51	1	Popliteal	44
		2	Popliteal + Femoro-poplit.	4
		3	Popliteal + Sup. Femoral/s	3
High**	26	4	Sup. Femoral/s	12
		5	Sup. Femoral/s + Femoro-poplit.	9
		6	Long Saphenous	2
		7	Femoro-popliteal	3
Low	23	8	Posterior tibials/s	23

* (Gastrocnemial + SSV in a common trunk: 1 case)
** (Double Superficial Femoral Vein: 8 cases)

examinations were performed. For this reasons a comparison between the two different methods could not be significant.

RESULTS

The results coming from every single method employed during the study and the total of the single anatomical variations observed over 528 limbs examined are shown in ***Table 2***.

Echography allowed us to detect the extention and direction of the SSV arch but showed us clearly only the normal termination into the popliteal vein, which is the most properly named SPJ with or without a direct flow in continuity into the femoro-popliteal (*Fig. 1*). In other cases a low termination into the posterior tibials was visualized. The SSV direction proximally in the thigh was detectable but the high termination into the femorals was hardly legible.

In two other cases (0,8% of the echographyc causistry - 0,3% of the total of the limbs examined) the gastrocnemial veins and the SSV were connected in a common trunk flowing into the popliteal as described by Hobbs (1980-1986).

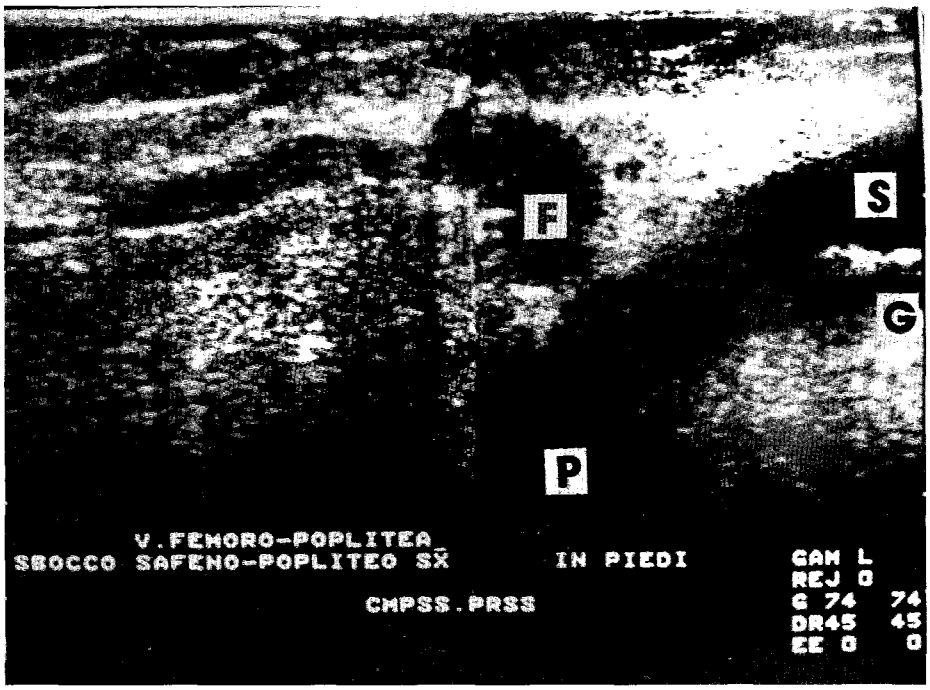

Fig. 1 - High Resolution Echography of the popliteal region in a subject with primary VVLL of the calf. A normal SSV outlet (S) into the popliteal (P) is visible. The SSV insufficiency was not due to a valvular incompetence of the SSV outlet but to an evident femoro-popliteal reflux. The median gastrocnemial (G) vein flowing into the SSV 2 cm. before the SPJ.

The extensive, multiple and contemporary visualization of the superficial and deep venous system of the lower limbs by preoperative Phlebography rendered difficult to differentiate all the normal communicating veins from the variations, and Digital Phleeeebography could visualize only a limited topographical area. For these reasons it was not advisable to divide the cases studied by preoperative Phlebography (traditional or Digital) into subgroups.

The single variations of the SSV outlet observed by intraoperative Selective Phlebography divided into 8 subgroups are shown in *Table 3*.

The superficial femoral vein was visualized by the latter examination in 27 cases.

In cases with "normal" termination (*Fig. 2*) the middle calf perforator (Gullmo 1972, May *et al.* 1981) was frequently visualized. This perforating vein drains in the posterior tibial/s. In one case a common trunk representing the outflow of the gastrocnemial and the SSV into the popliteal was visualized (*Fig. 3*).

In subgroup 3 the major communication of the SSV with the deep system was represented by a sapheno-popliteal arch and a minor communicating vein connected this arch with the superficial femoral below the Hunterian channel.

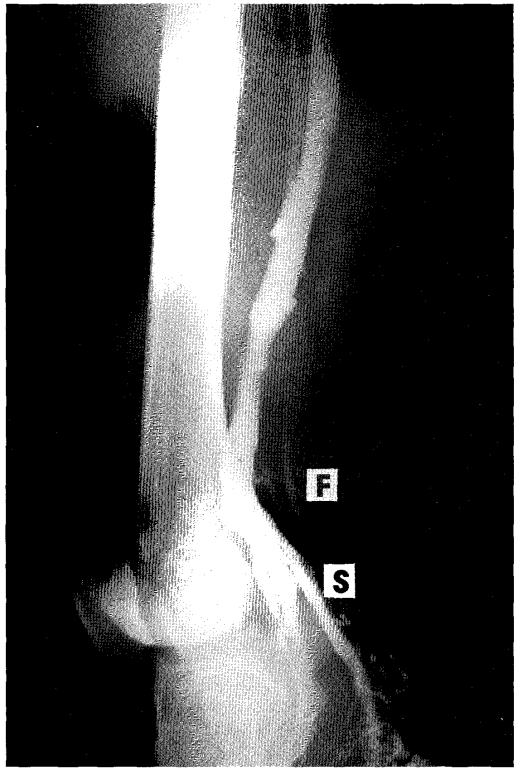

Fig. 2 - **Intraoperative** Selective Phlebography of the SSV. The SSV termination (S) is normally **located in the popliteal** region with a very thin femoro-popliteal ascending branch (F).

In subgroup 4 the outlet consisted with a direct communication of the SSV with the superficial femoral vein or with a double femoral by an additional small communicating vein in 2 of these cases connections were located above the Hunterian channel (*Fig. 4*).

In subgroup 5 the main outlet was representd by the femoro-popliteal vein in continuity and a small perforator connected this branch with the superficial femoral

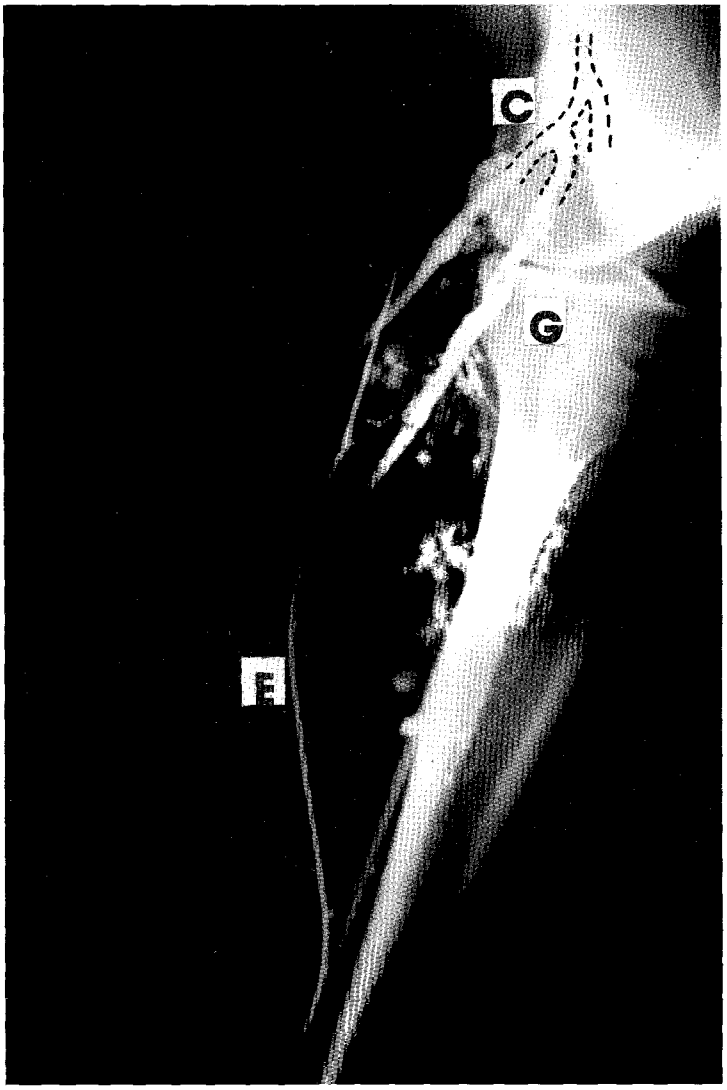

Fig. 3 - Intraoperative Selective Phlebography of the SSV. «Normal termination» of a common trunk (C) resulting from the conjunction of one gastrocnemial vein (G) with the SSV. An intraluminal Phlebo-extractpr (E) has already been inserted into the long saphenous vein.

system (one or two) below the Hunterian channel. In one of these cases a small communication was located above the channel.

The "low" termination (subgroup 8) was always located in correspondence of the middle calf perforator with or without an ascending hypoplasic branch up to the popliteal (*Fig. 5*).

In 8 cases of the 27 (29,6%) outlets into the femoral vein a duplicity of the latter was detected (*Fig. 4*).

Fig. 4 - Intraoperative Selective Phlebography of the SSV. High termination of the SSV which flows directly into an accessory superficial femoral vein above the Hunterian channel (2), while a very thin communicating vein joins the superficial femoral below the Hunterian channel (1).

DISCUSSION

What emerges from the results obtained by the different method used in the study is that Echography showed a lower number of anatomical variations of the SPJ and SSV outlet than the radiological examinations. (*Tab. 2*). These differences can be explained by the following considerations:

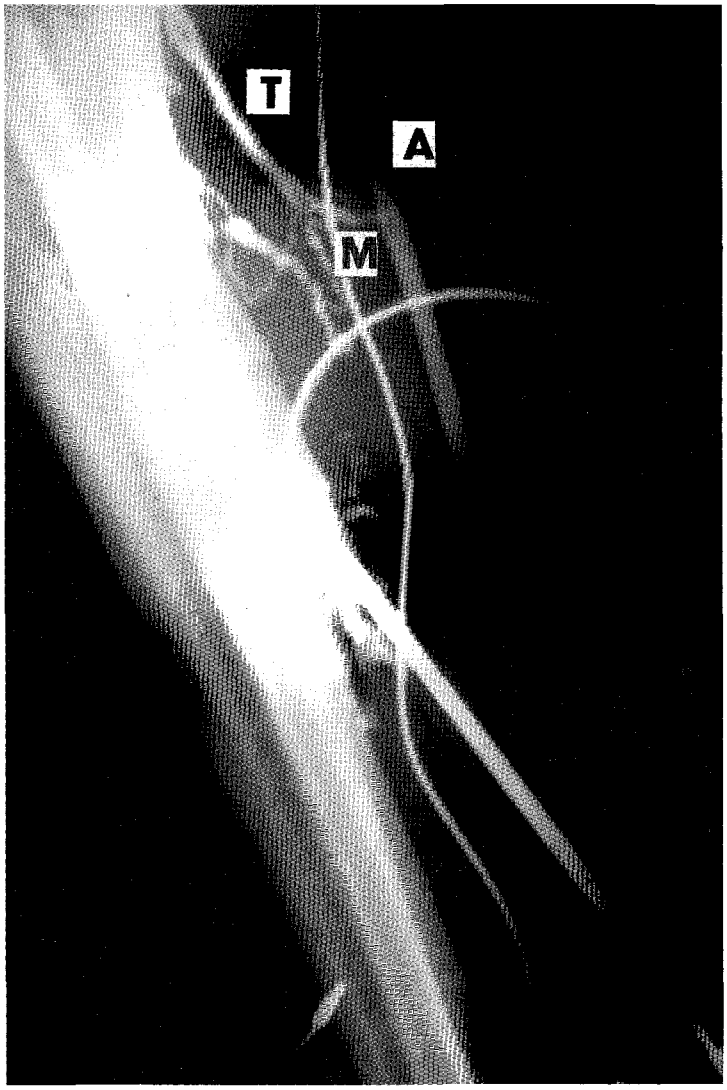

Fig. 5 - Intraoperative Selective Phlebography of the SSV. Low termination. The SSV drains into the posterior tibial (T) via the middle calf perforator (M) and is connected with the femoro-popliteal by a thin ascending branch (A).

— Echographic examinations were performed not only in patients suffering with venous disease and probably the anatomical variations of the SPJ and SSV are to be considered as co-factors in the development of the varicose disease (similarity of the SSV with a leg perforator described by Marques - 1989).
— deep veins of the thigh and small perforating and/or communicating veins (< 2 mm. diameter) are not easyly detectable by echography.

— In some cases of advanced venous disease venous wall calcifications covered the deep vessels.

However the radiological examinations showed a number of a variations very close to the other Author's data (compare *Tab. 1* with *Tab. 2*).

Finally the subgroups detected by intraoperative selective Phlebography are overlapping to the anatomical findings obtained by dissection of cadavers (Kosinski 1926) and this allowes to consider this radiological method the "gold standard" in the diagnostic investigation of the SPJ and SSV outlet according with other Authors (Hobbs 1980-1985, Jantet 1985).

One of the most notable variations in surgery is to be found where there is a low termination. It is extremely important for surgeons to asses the SSV outlet location before or during surgery in order to avoid long, traumatizing and useless dissections of the popliteal region.

The normal termination of the SSV in the popliteal vein was found in the 70% of cases studied comprising the single termination of the SSV in the popliteal vein and cases where the SSV has an ascending tributary which joins the femoral or femoro-popliteal veins. In these cases a surgical research of the SSV can be performed by careful dissection following the ascending tributaries. In 3 cases the SSV flowed directly in the femoro-popliteal with or without communications with the femoral/s.

It must be underlined the existence in the popliteal area of a rare common trunk resulting from the confluence of the SSV and gastrocnemial veins, which is to be considered as a typical SPJ variation (*Fig. 3*).

The femoro-popliteal (*Tab. 3*) was visualized in 13 of the 100 intraoperative Selective Phlebographies; it presence is extremely important, because it may represent a main spontaneous collateral circulation in cases with deep venous obstruction (*Fig. 6*).

CONCLUSIONS

Confirmation of the high number of anatomical variants (29,8% from the present study) shows how in fact the traditional interpretation of the SSV termination in the popliteal vein (SPJ) is not completely reliable and may cause difficulties not only in surgery but also in the diagnostic approach with aims to locate the vein and study its hemodynamic and morphological alterations.

In most cases ligation in the popliteal area is an incomplete treatment since the termination is either not to be found here or is hypoplasic if the vein continues upwards. If exploration begins at the popliteal region and the vein is not located, a low termination may be supposed. It follows that in the absence of clear preoperative indications it is better to begin the surgical research of the SSV at the external malleolus and that intra-operative phlebography is, at present, the only fast and sure method of locating the termination. With a clear picture of the situation,

Fig. 6 - Diagnostic Phlebography performed via a pretibial varicose vein. A 17 years old female suffering with multiple angiomatosis and arterial hypotrophic angiodisplasia developed a spontaneous deep venous thrombosis of the popliteal and superficial femoral veins. She developed secondary VVLL of the long saphenous district and was subjected to stripping of the latter. The femoro-popliteal vein (F) became varicose and drained the whole venous blood from the limb into the other side via the superficial pudendal (P) (spontaneous cross-over).

complete removal of the SSV can be carried out without risking serious damage to the deep veins.

Normally the outflow of the SSV in the deep veins is via an arch from the subcutaneous area to the intramuscular layers. The collateral veins join it before the

arch penetrates deeply. Ligation or dissection at this level is sufficient to perform complete posterior saphenectomy without continuing the dissection to deeper levels where there may be junctions with intramuscular veins which usually must not be disconnected. The common trunk described above represents one example of risk factor for the gastrocnemial veins during SSV surgery.

We may assume that the anatomical variants of the SSV are in some way linked to the onset and development of VVLL Detailed study of these conditions show that, where the SSV is connected to other venous districts, it may become subject to the phenomena of venous hypertension present in these districts and may be also held responsible for varicose conditions in other systems such as the long saphenous (Marques 1975). Reconsidering the hypothesis, confirmed by our histopathological studies, of the systemic nature of the varicose condition (Corcos *et al* 1986) and the part played by the SSV, we hold that attention should be concentrated here, particularly in the therapeutic stage.

On the other handt it must be said that a larger operator's experience in the echographic investigation of the SPJ and SSV makes possible a clear visualization of the SSV outlet in cases of normal, low and femoro-popliteal termination. In those with a high termination the SSV arch is usually detected and imaging details of the SSV outflow into the femoral/s are not fundamental for the achievement of effective surgery.

We may finally assume that H.R. Echography has demonstrated a high effectiveness in the examination of the larger number of cases. All patients should be systematically examined by this method and when echographic findings are somehow doughtful or a detailed study of collateral circulation is required the intraoperative phlebography is the ideal technique for the anatomical study of the SPJ and SSV outlet.

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