

# Ultrasonographic anatomy of the lower extremity superficial veins

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## ABSTRACT

A simple, precise, and consistent anatomical terminology is necessary for evaluating and treating patients with varicose veins. A clear understanding of the anatomy is also very important to correctly diagnose and perform the best treatment for varicose veins. Because the anatomy depicted by ultrasonography has many variations, anatomic definition for at least some of the veins still require clarification. Studies focusing on different segments of the veins are needed to obtain detailed anatomical knowledge given this great variability.

*Key words:* • saphenous vein • ultrasonography • anatomy  
• Giacomini vein

**M**inimally invasive treatment modalities that were developed in the last decade have simplified the treatment of varicose veins (1, 2). Proper evaluation of the venous system is crucial to the appropriate treatment of venous disorders. Grey scale ultrasonography (US) examination with color Doppler and spectral analysis has become increasingly important and is now used more frequently for the diagnosis and treatment of varicose veins. US is probably the simplest, most frequently used, and most effective method to evaluate the anatomy of varicose veins. In recent years, The Union Internationale de Phlebologie gave a recommendation on how to perform US investigation of veins in chronic venous disease of the lower limb (3).

Venous anatomy is very variable in some regions but is more consistent in other parts of the lower limb. In general, however, variability is much more pronounced in the veins than in the arteries. There is a wide range in the data concerning the reported incidence of tributary, duplicated or accessory veins related to the saphenous veins. This variability may reflect true variations in the venous anatomy or a lack of standardization in the terminology or anatomical definition of the lower extremity veins. The committee for official anatomical nomenclature, Terminologia Anatomica, drafted a document in 2001 that attempted to unify the terminology for the venous system, particularly in the lower limb, and refined this terminology in an addendum in 2005 (Table) (4, 5). Incorrect naming of the veins causes great confusion because of the many anatomical variations in the veins. A thorough understanding of the anatomy of veins and the proper use of terminology are very important to correctly diagnose and treat underlying venous insufficiencies and related varicose veins.

The purpose of this article is to review the new terminology and US-based anatomy of the saphenous veins as well as the other superficial truncal veins of the lower extremity. Although much has been done in the last decade to unify the terminology and to define the anatomy of the lower extremity veins, certain questions still need to be answered regarding the anatomy of the lower extremity veins.

## Fascial relationships of the great and small saphenous veins

A thorough knowledge of the fascial layers and compartments of the leg is a prerequisite for understanding the anatomy and relationship among superficial veins (6–9). The muscular fascia surrounding the calf and leg muscles separates two compartments: the superficial compartment that consists of all tissues between the skin and the muscular fascia, and the deep compartment, which includes muscles and deep veins that lie beneath the muscular fascia (Fig. 1). The veins of the lower extremities are divided into three systems: 1) the superficial veins that are located in the superficial compartment above the muscular fascia and

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**Table.** Comparison of the valid Latin and English terms of the superficial veins of the lower limb in Terminologia Anatomica 1998, consensus documents from 2001 and 2004, and their obsolete synonyms

Valid Latin term	Valid English term	Obsolete synonyms
<i>Vena saphena magna</i>	Great saphenous vein	Long saphenous vein Greater saphenous vein
<i>Vena saphena parva</i>	Small saphenous vein	Short saphenous vein External saphenous vein Lesser saphenous vein
<i>Vena saphena magna accessoria anterior</i>	Anterior accessory great saphenous vein	Pre-saphenous arch vein (in thigh) Anterior saphenous vein of leg Anterior superficial tibial vein Vena arcuata cruris anterior Anterior tributary vein (in leg) Anterior calf vein
<i>Vena saphena magna accessoria posterior</i>	Posterior accessory great saphenous vein	Post-saphenous arch vein (in thigh) Posterior leg vein Vena arcuata cruris posterior
<i>Vena circumflexa femoris anterior</i>	Anterior thigh circumflex vein	Lateral accessory saphenous vein Anterolateral (superficial) vein of the thigh Anterior lateral tributary
<i>Vena circumflexa femoris posterior</i>	Posterior thigh circumflex vein	Medial accessory saphenous vein Posteromedial (superficial) vein of the thigh Posteromedial thigh vein Posterior medial tributary
<i>Extensio cranialis vena saphena parva</i>	Cranial extension of small saphenous vein	Vena femoropoplitea Vena subcutanea femoris Femoropopliteal vein Thigh extension of the small saphenous vein
-	Giacomini's vein	Vena giacomini Vena femoralis posterior Vena saphena accessoria medialis
<i>Systema venosum laterale membri inferioris</i>	Lateral venous system	Lateral thigh vein Lateral subdermic (venous) system

drain the cutaneous microcirculation, 2) the deep veins that lie beneath the muscular fascia and drain the lower extremity muscles, and 3) the perforating veins that penetrate the muscular fascia and connect the superficial and deep veins.

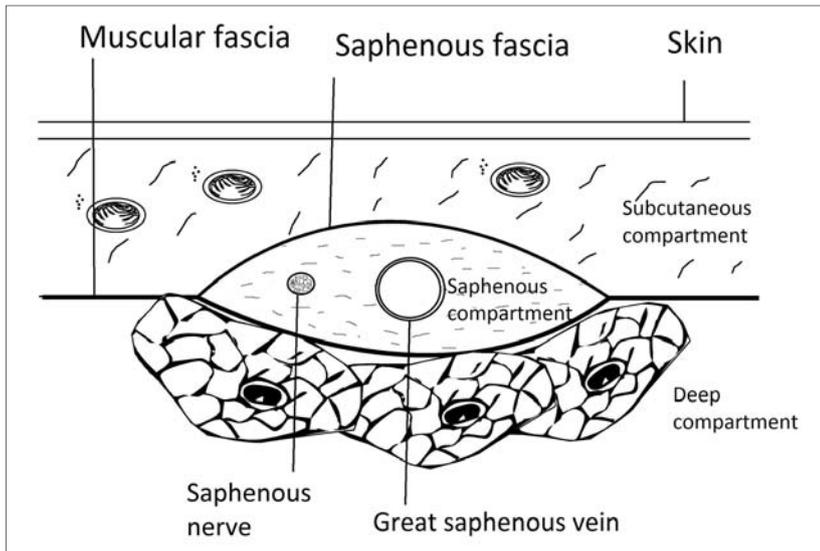
The superficial compartment is composed of subcutaneous tissue that contains the saphenous veins and their tributaries. The saphenous fascia is the portion of the membranous layer of the subcutaneous tissue that overlies the saphenous veins. The saphenous fascia is thinner than muscular fascia. All fascias appear hyperechogenic on US. The two fascial layers, with the saphenous fascia above and muscularis fascia below, merge at each end to form a closed space, which is called the saphenous compartment (Fig. 1) (8). The saphenous compartment contains the saphenous vein and the accompanying arteries and nerves. The

saphenous nerve is usually far from the great saphenous vein (GSV) and not in the saphenous fascia above the knee. However, the saphenous nerve lies in close proximity to GSV and is located in the saphenous fascia distal to the knee. The only truncal vein located in the saphenous compartment is the GSV or its duplicate (Fig. 2). All of the tributary veins and accessory veins are located in the subcutaneous compartment, external to the saphenous fascia and the saphenous compartment. The saphenous fascia and the muscularis fascia as well as the saphenous compartment with the saphenous vein in the middle form the "Egyptian eye" or "the ultrasonographic eye sign" (10, 11). The compartment in which the saphenous veins run resembles an eye in the transverse scan, where the saphenous lumen is the iris, the saphenous fascia is the upper eyelid, and the muscular fascia is the lower eyelid (Fig.

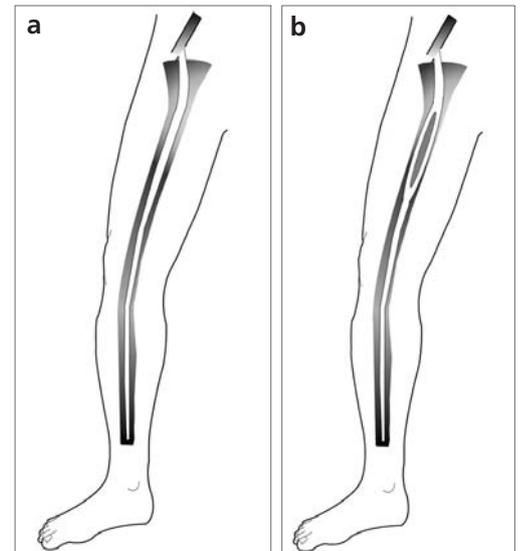
3). The terminology for the fascia surrounding the saphenous vein and the compartments is the same for both the GSV and small saphenous veins (SSV).

### The great saphenous vein (*Vena saphena magna*)

The term GSV should be used instead of terms such as long, greater, or internal saphenous vein. The GSV is the longest vein in the body; this vein begins at the medial marginal vein of the foot and terminates at the saphenofemoral junction (SFJ) approximately 3 cm below the inguinal ligament. The GSV is deep in the subcutaneous tissue and lies on the muscular fascia. The GSV has a constant terminal valve 1–2 mm distal to the SFJ in 94%–100% of the cases (12). There is often another pre-terminal valve that is 2 cm distal to the constant terminal valve. Some important tributaries join the GSV between the two valves, which are consistent



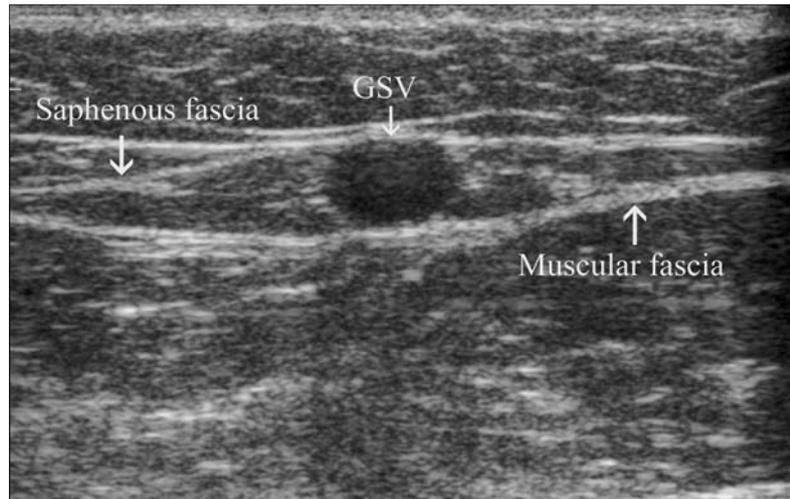
**Figure 1.** The muscular fascia separates the subcutaneous compartment from the deep compartment. The saphenous compartment belongs to the subcutaneous compartment and contains the saphenous vein. All of the tributary veins and accessory veins lie outside the saphenous compartment.



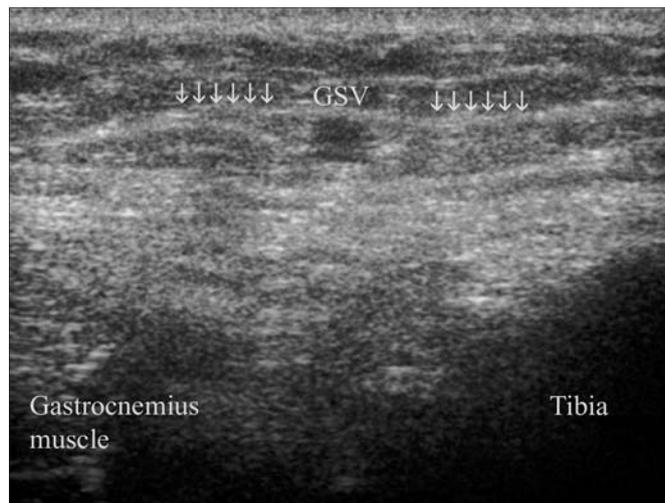
**Figure 2. a, b.** The zone in gray shows the saphenous compartment. The vein located in the saphenous compartment is either the saphenous vein itself (a, great or small saphenous vein) or its duplicate (b).

and can be readily identified by US. They drain venous blood from the abdominal wall and pudendal areas. These tributaries are the superficial circumflex iliac vein, superficial epigastric vein, and superficial external pudendal vein. Proximal veins may transmit retrograde flow into the GSV even when there is a competent terminal valve, as is reported in 28% to 59% of cases. The preterminal valve prevents reflux from proximal veins into the distal GSV. The GSV has 10–20 valves, with the majority found in the leg.

The saphenous fascia is reported to be well formed in the upper thigh. The fascia is also well formed in the lower leg. The saphenous and tributary anatomy becomes increasingly complex due to interruptions and variability of the saphenous fascia around the knee compared with the proximal thigh or distal calf region. The tibio-gastrocnemius angle sign has been reported to aid in the identification of the GSV around the knee if the vein is within the saphenous compartment (13). The tibio-gastrocnemius angle or triangle is formed by the tibia and the medial gastrocnemius muscle on both sides as well as the fascial sheet superficially (Fig. 4). A vein found within this triangle was considered to be a definitive sign for the identification of the GSV. This sign may not be helpful if there is segmental hypoplasia of the GSV, where a segment of the GSV is located outside the saphenous compartment.



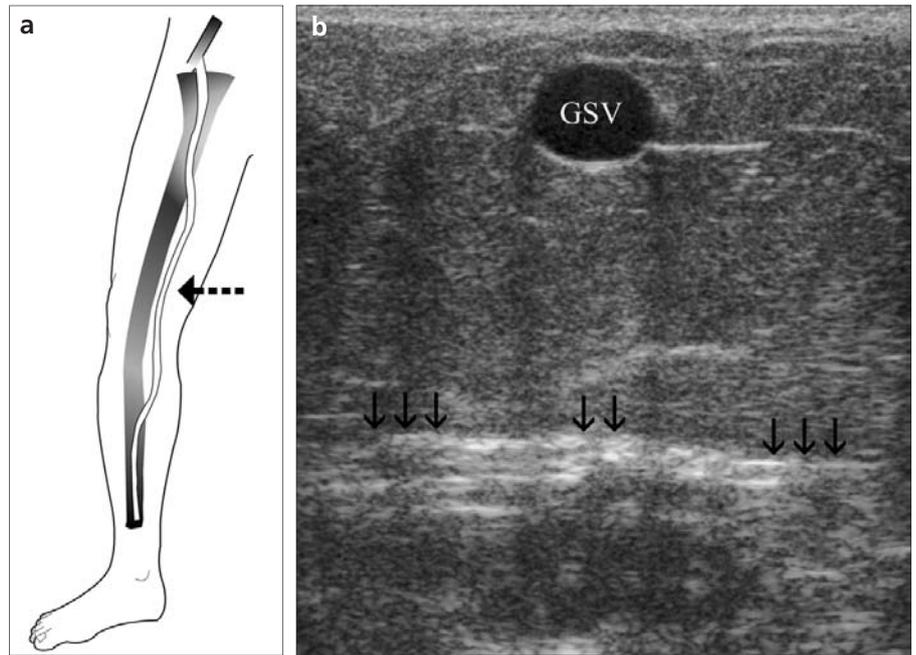
**Figure 3.** Transverse US imaging of the “Egyptian eye”; the saphenous fascia is the upper eyelid, the muscular fascia is the lower eyelid, and the saphenous vein is the eye. The nerve is usually not visible. GSV, great saphenous vein.



**Figure 4.** The GSV in the knee area is distinguishable from the tributaries or accessories by its position on a transverse US scan in a triangle formed by the medial border of the tibia and the gastrocnemius muscle, along with a line formed by the saphenous fascia (arrows). In a case of segmental hypoplasia of the GSV, there will be no vein in this triangle. GSV, great saphenous vein.

### Hypoplasia of the GSV

The GSV is almost always present in the saphenous compartment in the upper thigh and lower leg regions. However, the GSV may be diminished in caliber or not visualized at all in some segments along the saphenous compartment and is called segmental hypoplasia of the GSV (14, 15). The etiology of GSV hypoplasia is unknown but could be secondary to a primitive defect occurring during development. A subcutaneous tributary vein connects the two segments of the GSV in most cases. In its most common form, the GSV pierces the saphenous fascia at the mid-calf to become a subcutaneous tributary, which courses upwards crossing the knee and again pierces the saphenous fascia at the mid-thigh region to become the GSV in the saphenous compartment (Fig. 5). The vein that connects the proximal and distal parts of the saphenous vein acts as a bridging vein, which was called the saphenous accessory vein (15). However, the term saphenous accessory for the bridging vein may not be appropriate according to recent terminology for accessory veins. The distal normal GSV may sometimes terminate by directly draining into a perforator just distal to the hypoplastic segment (15). The proximal normal GSV in the saphenous compartment may be a continuation of a tributary, which means that sometimes no connection exists between the lower and upper parts of the GSV in its compartment. This finding is important because if there is a bridging vein connecting the two ends of the veins, incompetence at the proximal part is usually transferred to the distal part. If there is no connection between the two segments of the GSV, then only one segment may develop incompetence. Segmental hypoplasia is present in 25% of limbs with GSV reflux due to SFJ incompetency and in 12% of limbs in normal subjects ( $P < 0.01$ ) (15). Another study also showed that the incidence of a segmental hypoplasia of the GSV was higher in patients with varices than in normal subjects (43% versus 30%; statistical significance is not defined) (13). The higher incidence of segmental GSV hypoplasia in patients with clinically apparent varicose veins may play a causative role in the pathogenesis of varices (13, 15). Despite the high incidence of hypoplasia of the GSV, it has been



**Figure 5. a, b.** In segmental hypoplasia of the GSV, the saphenous vein is not visible in the saphenous compartment (a, gray zone). A bridging vein connects the distal and proximal parts of the GSV (a). The arrow in the diagram shows the position of the US transducer for Fig. 5b. US image shows the superficial location of the bridging vein (b). Arrows delineate the muscular fascia (b). GSV, great saphenous vein.

mentioned rarely in the literature. The so-called accessory vein that accompanies and bypasses the hypoplastic segment is often erroneously considered to be the GSV itself. However, a vein can be identified as the GSV only if it is within the saphenous fascia and the bridging vein is located outside of the saphenous fascia.

US imaging based on fascial relationships reveals several GSV patterns (10–11, 16).

- 1) A single GSV can be found within the entire length of the saphenous compartment. There may or may not be a large tributary joining the GSV (Fig. 2).
- 2) When true duplication is present, there are two GSVs in the saphenous compartment (Fig. 2).
- 3) The middle portion of the GSV is barely visible (<1 mm in diameter) or not visible at all (hypoplastic or absent) for a variable length in approximately 30% of the cases, with a subcutaneous tributary bypassing the missing section (Fig. 5).

This classification could not be applied in 3% of cases.

### Duplication of the GSV

The incidence of double GSV is reported to be between 1% and 86% in

different studies due to the lack of a clear definition of duplication and a lack of objective parameters for identification (17). True duplication of the GSV occurs when there are two venous trunks running parallel to each other within the same saphenous compartment. Recent studies showed that true duplication of the GSV is observed in 1% of the population and exclusively in the thigh and never in the leg (17). The accessory saphenous veins or large tributaries running parallel to the GSV, but not in the saphenous compartment, were the main cause of erroneous diagnosis of a double GSV. A tributary vein may course along the GSV for a distance in the saphenous compartment and then join the GSV. The presence of this tributary vein should not be confused with GSV duplication. A detailed US evaluation of the distal part of the joining vein will indicate that it is a tributary vein and not a duplication of the GSV.

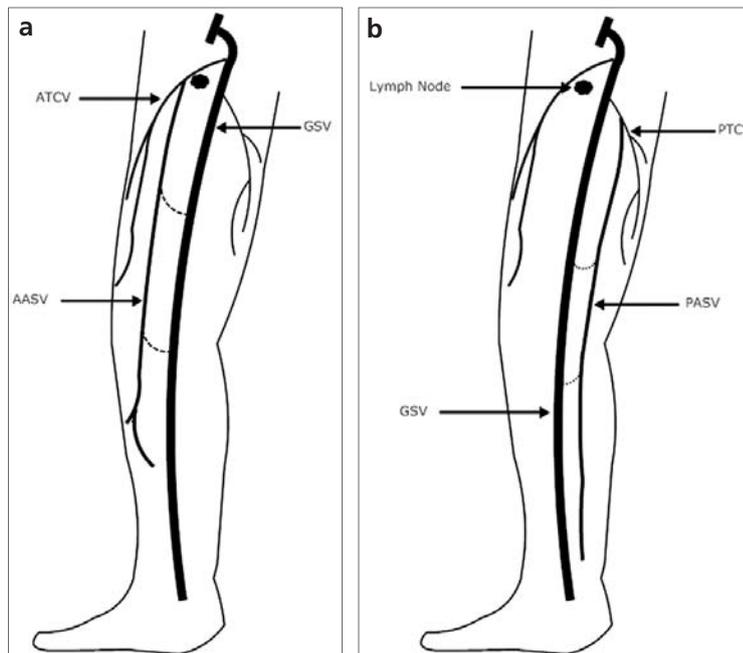
### Tributary veins to the GSV

Tributaries are defined as veins that run obliquely or beside the tract of the associated saphenous vein but that are not situated within the saphenous compartment (10). These

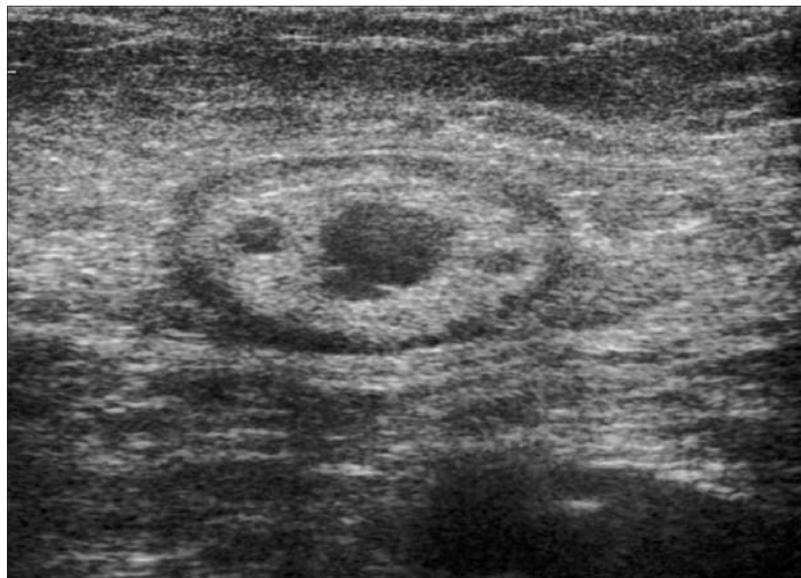
veins may be so large that they may be confused with an accessory or the GSV itself or considered to be a duplication of the saphenous veins. US examination shows that these veins lie outside of the saphenous compartment but pierce the saphenous fascia at some point, entering the saphenous compartment to drain into the saphenous vein. A tributary vein may be the main axial superficial vein but is not the saphenous trunk, as it lies outside the saphenous compartment (10). Dilated and tortuous veins visible on the medial aspect of the thigh and leg are frequently considered to be varicose GSVs. However, dissection and imaging studies demonstrate that in most cases, the visible varicose veins of the medial thigh and leg are saphenous vein tributaries (18). Anterior and posterior thigh circumflex veins are among the many tributaries of the GSV in the thigh. Two main saphenous tributaries are usually observed in the calf, an anterior branch and a posterior arch (Leonardo's) vein, the latter of which begins behind the medial malleolus and joins the GSV just distal to the knee.

The anterior thigh circumflex vein is a tributary vein of the GSV that ascends obliquely in the anterior thigh (Fig. 6). The draining point to the GSV is 2 to 3 cm inferior to the SFJ and is quite constant. This draining point may originate from the lateral venous system and drain the subcutaneous tissues of the anterolateral thigh, which is why the vein was formerly named the anterolateral vein (18). The tributaries of the anterior thigh circumflex vein are located laterally in the thigh. They unite and enlarge as they course obliquely and then form the main trunk to join the GSV. The main trunk courses anterior to an inguinal lymph node and then drains into the GSV near the SFJ (19). This lymph node is quite constant, and a vein draining this lymph node usually joins the anterior thigh circumflex vein. Insufficiency of this vein causes a typical appearance involving anechoic dilated veins in the lymph node (Fig. 7).

The posterior thigh circumflex vein (formerly the posteromedial vein) is a tributary vein of the GSV that ascends obliquely in the posteromedial thigh (Fig. 6). This vein may originate directly from the SSV, in its cranial extension, or in the lateral venous system (4,



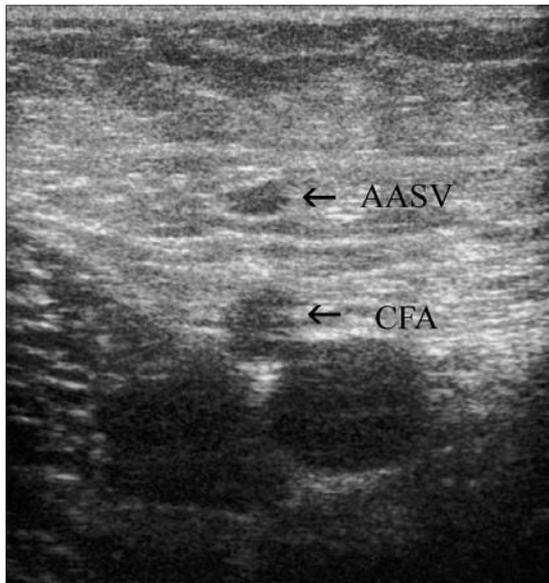
**Figure 6. a, b.** The ATCV (a) drains the subcutaneous tissues of the lateral parts of the thigh. The AASV is located between the ATCV and the GSV, usually joins the ATCV and drains as a trunk into the GSV (a). The PTCV (b) drains the subcutaneous tissues of the medial parts of the thigh. The PASV vein is located between the PTCV and the GSV, usually joins the PTCV and drains into the GSV (b). ATCV, anterior thigh circumflex vein (formerly anterolateral vein); AASV, anterior accessory saphenous vein; PTCV, posterior thigh circumflex vein (formerly posteromedial vein); PASV, posterior accessory saphenous vein; GSV, great saphenous vein.



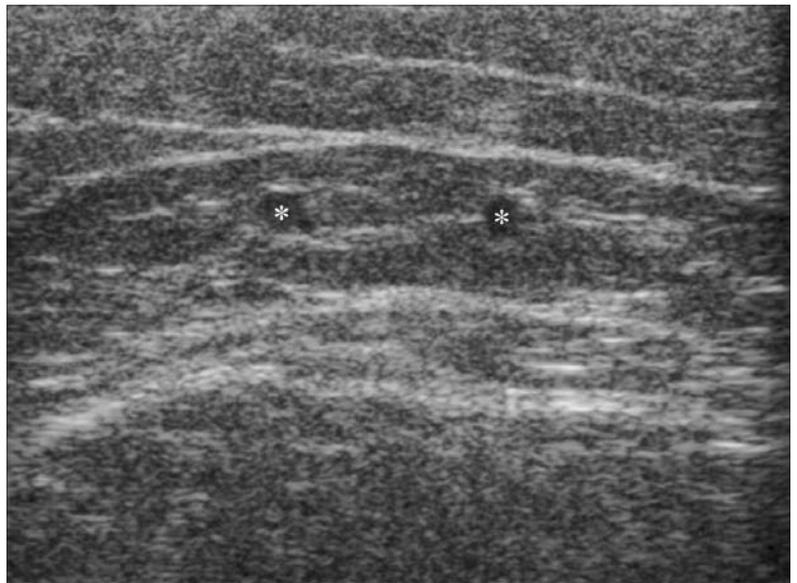
**Figure 7.** Venous drainage of this lymph node constantly found in the inguinal area is usually anterior to the thigh circumflex vein near its drainage point to the GSV. Insufficiency of the anterior thigh circumflex vein may cause insufficiency of the vein draining the lymph node, resulting in dilated veins in the lymph node.

5). It drains the subcutaneous tissues of the posteromedial thigh. The branch of the thigh extension of SSV that ascends medially and becomes a branch of the posterior thigh circumflex vein is called the Giacomini vein.

The lateral venous system is another tributary that joins the GSV. The lateral venous system of subcutaneous veins is found on the lateral aspect of the thigh and leg and is a developmental remnant of the embryonic lateral marginal vein.



**Figure 8.** The AASV, if present, usually aligns with the CFA in the proximal thigh, distinguishing itself from the great saphenous vein that is almost always located medial to the artery. AASV, anterior accessory saphenous vein; CFA, common femoral artery.



**Figure 9.** There are two small saphenous veins in the saphenous compartment consistent with true duplication (asterisks).

An abnormally developed lateral venous system can be observed in patients with Klippel-Trenaunay syndrome.

#### Accessory saphenous veins

The accessory saphenous veins are not constant and are only occasionally found. They are defined as those venous segments that ascend parallel to the saphenous veins, anterior, posterior or more superficial to the main trunk (5, 10, 18).

Anterior accessory saphenous vein (AASV) refers to a venous segment that ascends parallel and anterior to the GSV in the thigh (Fig. 6) (5, 10). It is located anteriorly to the GSV and usually lies in the same saphenous compartment that extends medially and laterally in the proximal thigh (10). The AASV is found in 14% of patients with varicose veins (10). It usually drains to the anterior thigh circumflex vein. The AASV is sometimes large and incompetent and can cause reflux into the thigh and leg veins when the GSV is competent. Alternatively, there may be reflux in both the GSV and AASV (11). The AASV can be confused with and should be differentiated from the GSV. US examination shows that the AASV is in alignment (alignment sign) with the femoral artery in the proximal thigh. It lies anterior and lateral to the GSV (Fig. 8). GSV is almost always

medial to the femoral artery and vein along its course. A study reported that in some limbs, the only vein forming an Egyptian eye is the AASV because the GSV is not always visible (absent or hypoplastic) (15). However, this statement is controversial as the GSV is usually well formed and constant in the upper thigh and because the AASV does not contain a fascia in the lower thigh or in the upper leg where the GSV may be hypoplastic or absent.

The posterior accessory saphenous vein (PASV) indicates any venous segment that ascends parallel to the GSV and is located posteriorly, both in the leg and in the thigh (Fig. 6) (5, 10). The PASV is contained within a fascial compartment in the thigh. This vein is not found as often as the AASV is found, and its connection with the GSV is not always constant.

The term superficial accessory saphenous vein is less frequently used and indicates any venous segment that ascends parallel to the GSV and is located more superficially, above the saphenous fascia, both in the leg and in the thigh (5).

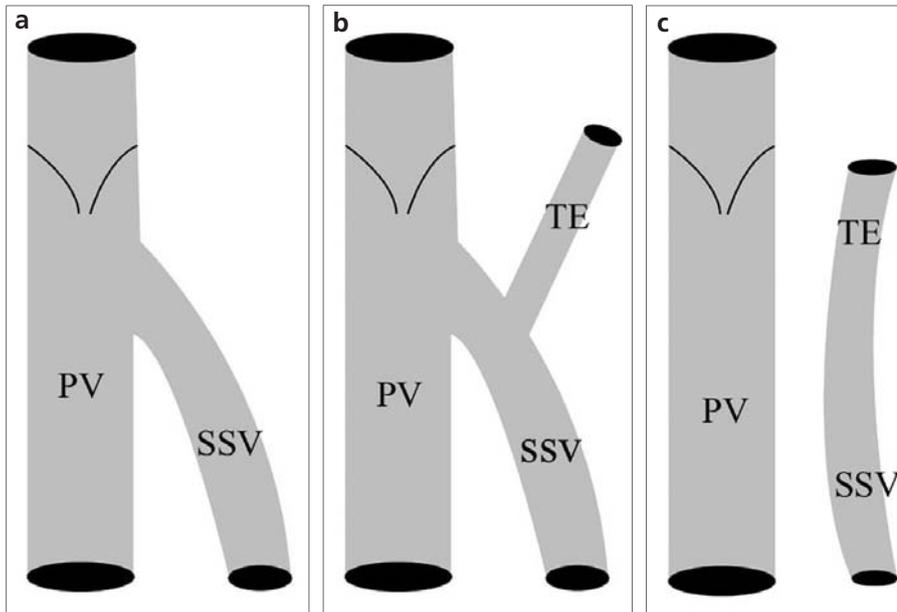
#### The small saphenous vein (*Vena saphena parva*)

The term SSV should be used instead of short, external, or lesser saphenous vein. The SSV begins behind the lateral

malleolus as a continuation of the lateral marginal foot vein. It usually has another tributary from the posteromedial side of the ankle. It communicates with the deep veins on the dorsum of the foot, receives numerous cutaneous tributaries from the back of the leg, and sends several branches superiorly and medially to join the GSV. It is close to the sural nerve. The fascial relationships of the SSV are more stable. There is no defined segmental hypoplasia. The fascia is constant throughout the course of the SSV. The SSV is occasionally duplicated (4%) with two or even three veins of various lengths found in one compartment (Fig. 9) (9). The medial and lateral veins coming from the foot may mimic duplication of the SSV as they ascend and approach each other. However, US examination of the distal leg shows that they are the two main tributaries forming the SSV proximally. The SSV has 7 to 13 valves, with one near its termination in the popliteal vein.

The termination of the SSV is variable and three patterns have been defined (Fig. 10) (10, 20):

- 1) The SSV joins the popliteal vein at the saphenopopliteal junction.
- 2) The SSV continues superiorly as the thigh extension or the vein of Giacomini, and it connects with the popliteal vein through an anastomotic vein.



**Figure 10.** a–c. The SSV may terminate in the PV (a); one branch of the vein may join the popliteal vein, while another may extend up as the cranial or TE (b). SSV sometimes does not have a direct relationship with the popliteal vein but extends up as the thigh extension (c). SSV, small saphenous vein; PV, popliteal vein; TE, thigh extension.

- 3) There may be no connection to deep veins in the popliteal fossa, and the SSV may continue proximally as the thigh extension or the vein of Giacomini.

Classifications of SSV termination have varied in different studies. The classical knowledge that the SSV terminates at the popliteal fossa in the popliteal vein alone is not included in some classifications (10). However, many studies have reported that the SSV ends in the popliteal vein alone in a majority of cases (9, 20). The saphenopopliteal junction is most often found within 5 cm of the popliteal skin crease. A higher location is also normal (21). The SSV joins the popliteal vein on its posterior aspect, lateral aspects or rarely even its anterolateral aspects (22). The terminal part of the SSV has two valves similar to the GSV: the terminal valve, which is in close proximity with the popliteal vein, and the preterminal valve, which is usually located below the thigh extension of the SSV. The gastrocnemius vein may join the popliteal vein, upper SSV, or the confluence of the saphenopopliteal junction (23). Tributaries of the SSV usually have high degrees of variation. However, there are unique tributaries of the popliteal vein around the popliteal fossa, called the popliteal area

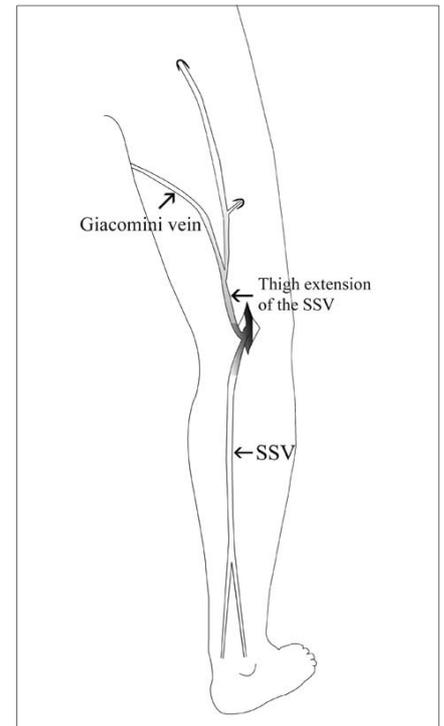
veins, that are found in 40% of cases (24). The popliteal area vein can be a single dilated vein or a cluster of veins that arise from the lateral aspect of the popliteal fossa.

#### The thigh extension of the small saphenous vein

The thigh extension or the cranial extension of the SSV was formerly called the femoropopliteal vein. This vein courses in the groove between the biceps femoris and semimembranosus muscles and is present in 72% to 95% of limbs (20). In 1873, Giacomini described the thigh extension of the SSV and its frequent connection to the GSV (20). This extension terminates in one or more superficial or perforating veins of the thigh or gluteal region or can join the deep femoral vein as a posterior thigh perforator (Fig. 11). In many cases, the proximal termination of the thigh extension is a combination of these veins.

#### Giacomini vein

The Giacomini vein is a thigh extension of the SSV that extends up to the posterior thigh, travels medially and joins the posterior thigh circumflex vein before draining into the GSV (Fig. 11). This is an intersaphenous vein. Intersaphenous veins (vena



**Figure 11.** The thigh extension of the SSV may join the femoral vein via a perforator, extend up to terminate in a gluteal vein, or extend up and medially to join the posterior thigh circumflex vein to form the Giacomini vein. SSV, small saphenous vein.

intersaphena) are tributaries to the saphenous veins that course obliquely in the leg or thigh to connect the SSV and GSV. They are found mostly in the calf region. The Giacomini vein usually lies in a groove between the semitendinosus muscle medially and the long head of the biceps muscle laterally. The thigh extension and Giacomini vein may transmit reflux from the proximal incompetent veins (e.g., GSV) to the SSV or vice versa, and may transmit an “ascending reflux” from the saphenopopliteal junction superiorly to the GSV. In 14% of population, the SSV continues directly as the Giacomini vein into the GSV (18). The prevalence of the vein varies between 2.5% and 86% (20, 25).

#### Veins along the course of the sciatic nerve

Veins along the course of the sciatic nerve are actually deep veins that are important when percutaneous treatment with sclerotherapy or endovenous thermal ablation is considered. Veins that enter the sciatic nerve or its

branches are called sciatic nerve veins. A large vein running along the course of the sciatic nerve but not within it is termed the persistent sciatic vein. The prevalence of reflux in veins along the course of the sciatic nerve is approximately 1% (26). Normal veins in or around the sciatic nerve are not visualized using US because of their small size. Incompetency of the veins along the sciatic nerve causes dilatation of the veins, which in turn produces symptoms and signs related to sciatic nerve irritation in addition to those resulting from chronic venous insufficiency (27). Endovenous thermal ablation of these varicose veins, although it would not be possible due to their tortuous anatomy, should be considered as a contraindication because thermal energy may damage the adjacent sciatic nerve.

### Perforating veins

Perforating veins are those veins that perforate the muscular fascia to connect the superficial veins with the deep veins. There are as many as 150 perforating veins in the lower extremity, although only a few of these are clinically important (18). Perforating veins are very variable in both size and distribution, and the medial calf perforators are probably the most important. The terminology for the perforating veins should designate locations, and perforators are grouped into those of the foot, ankle, leg, knee, and thigh.

### Conclusion

A simple, precise, and consistent anatomical terminology is necessary for the evaluation and treatment of patients with varicose veins. The terminology of the lower extremity venous anatomy has become more uniform after consensus meetings. A clear understanding of the anatomy is also very important to correctly diagnose and perform the best treatment for varicose veins. Because the anatomy depicted by US has many variations, anatomic definition of at least some of the veins

still needs clarification. Studies focusing on different segments of the veins are required to have detailed anatomical knowledge since there is great variability.

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The authors declared no conflicts of interest.

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