OBSERVATIONS ON THE SUPERFICIAL VENOUS SYSTEM OF THE LOWER EXTREMITY

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THE common liability of the superficial venous system of the lower extremity to varicosis has naturally attracted the attention of investigators and a great many memoirs have been written on this subject from the anatomical, physiological and pathological points of view. Among the more important anatomical studies I might mention the memoir by Giacomini (10) who investigated 51 limbs. His anatomical conclusions agree in general with my own: I shall refer to them in detail later. Bardeleben (3), Delbet (8), Klotz (17) and Rima (24) paid particular attention to the valves of these veins. Klotz regarded insufficiency of the valves as the main cause of the varicose condition. This opinion, however, was based on a study of 11 limbs only. Le Dentu (9) investigated the anastomoses between the superficial and deep veins. Houzé (12) contributed a detailed account of the position of and intervals between the valves. Nicholson (22) has recorded the interesting observation that the valves near the termination of the great saphenous are usually healthy even in varicosis.

Despite the many investigations there is no unanimity of opinion about the causation of varicose veins, nor, amongst surgeons and pathologists, a real appreciation of the anatomical facts.

Although attention has been mainly directed to the great saphenous vein for the elucidation of the causation of the varicose condition, the study of the small saphenous vein, which phylogenetically is the more important vein, throws a clearer light upon the problem.

The predisposing cause of varicosis must be the pressure of the long column of blood in the great saphenous vein and the lack of muscular support such as the deeper veins receive. Despite this general predisposition however, varicosis occurs infrequently and then usually in healthy adult people between 20 and 40 years of age (Bergmann (2)).

Several writers state that to a certain extent there is an hereditary tendency to the disease, and according to Magnus in one-half to three-fourths of the cases.

The object of this note is to show that this hereditary factor may be expressed in the modes of arrangement of the superficial veins.

METHOD AND MATERIAL

Altogether I examined 124 legs, of which 70 were males and 54 females, and 66 right and 58 left. In several cases the dissection was facilitated by the use of an injection mass of Berlin blue and gelatine.

I directed particular attention to the following points:

I. The *anatomy* of the small saphenous vein and the relations of its *terminations.*

II. The definite anatomical *anastomoses* of the great saphenous vein with the deep veins of the leg.

I. *Small Saphenous Vein.*

(*a*) It *begins* behind the lateral malleolus where it receives the veins from the lateral portion of the dorsum of the foot, lateral malleolus, and the lateral side and back of the heel. These veins join together to form the small saphenous on an average 2 cm. above the tip of the lateral malleolus. In 20 per cent. this junction was symmetrical in the right and left limbs.

(*b*) The average *diameter* of the vein was 3 mm., the range being from 1 mm. to 4 mm. In 28 per cent. of cases there existed a difference of diameter between the upper and lower half of the vein, and in most of these cases (21 of the 28) the diameter was greater in the lower part. The diminution was from ½ to 1½ mm. and was due to the presence of anastomoses between the small and the great saphenous veins in the middle of the leg. In one-third this difference was present on both sides of the same body.

(*c*) *Its relations to the fascia of the leg.* A great difference of opinion concerning this subject exists. Some writers (Sappey, Hovelacque, Chrétien) claim that it runs under the deep fascia in the upper half; others (Cruveilhier, Malgaigne, Gegenbaur, Gray) that it runs between the superficial and the deep fascia; and others again that it runs between the layers of the superficial fascia (Richet, Tillaux, Cunningham). In the opinion of Spalteholz it runs in the deep fascia, in the so-called "canal aponevrotique" of French authors.

In the great majority of cases (75 per cent.) I found that the vein pierced layers of the superficial fascia to gain the interval between the superficial and deep fascia. The point of piercing was, on an average, in the middle of the leg, the range being from 20 to 75 per cent. of the length of the leg. Only in one-fourth of the cases did it pierce the deep fascia also in the upper third of the leg. Occasionally it coursed between the layers of the superficial fascia on the whole length of the leg. In two cases the vein ran between the superficial and the deep layers in the whole of its course and in three cases it was superficial even to the superficial fascia running just under the skin.

(*d*) Its *relations to the medial sural nerve.* In the majority of cases these relations are extremely variable. In more than half (66 per cent.) of the cases the vein is directly superficial to the nerve in the upper third of the leg; in the middle of the calf it is medial and in the distal third it is lateral to the nerve.

In about one-third of the cases (30 per cent.) the vein is altogether on the

medial side of the nerve, and in about 12 per cent. of the cases the vein is on its lateral side.

Nearly always in the upper half of the leg the nerve is separated from the vein by the deep fascia, and very often also by the connective tissue joining the two heads of the gastrocnemial muscle.

The relations between vein and nerve were the same on both legs of the same body in one-third of the subjects examined.

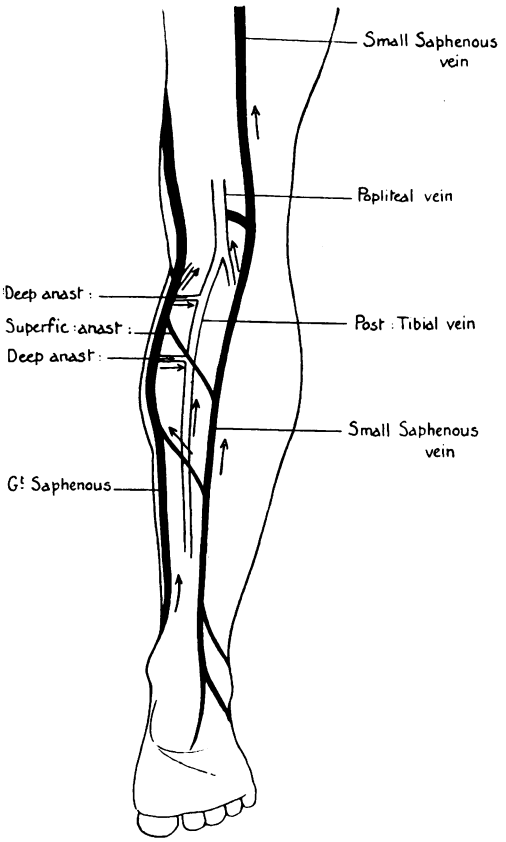

Fig. 1. Small saphenous vein pouring blood into both the popliteal and the great saphenous.

(*e*) ***Relations of the small to the great saphenous and to the deep veins of the leg.*** Usually two to four venous anastomoses join these two superficial vessels, the most constant ones being found in the middle of the leg (figs. 1–3). The main anastomotic vessels run from below upward, and from without from the small saphenous vein inward, to the great saphenous. The valves are so arranged that the blood current flows from small saphenous to great saphenous. The injection mass always flows from the small saphenous to the great saphenous. When the direction of the injection mass is altered (i.e. injected from above) no

injection mass reaches the small saphenous even by great pressure. On the other hand, it is easy to distend the great saphenous vein when the injected mass starts from the small saphenous.

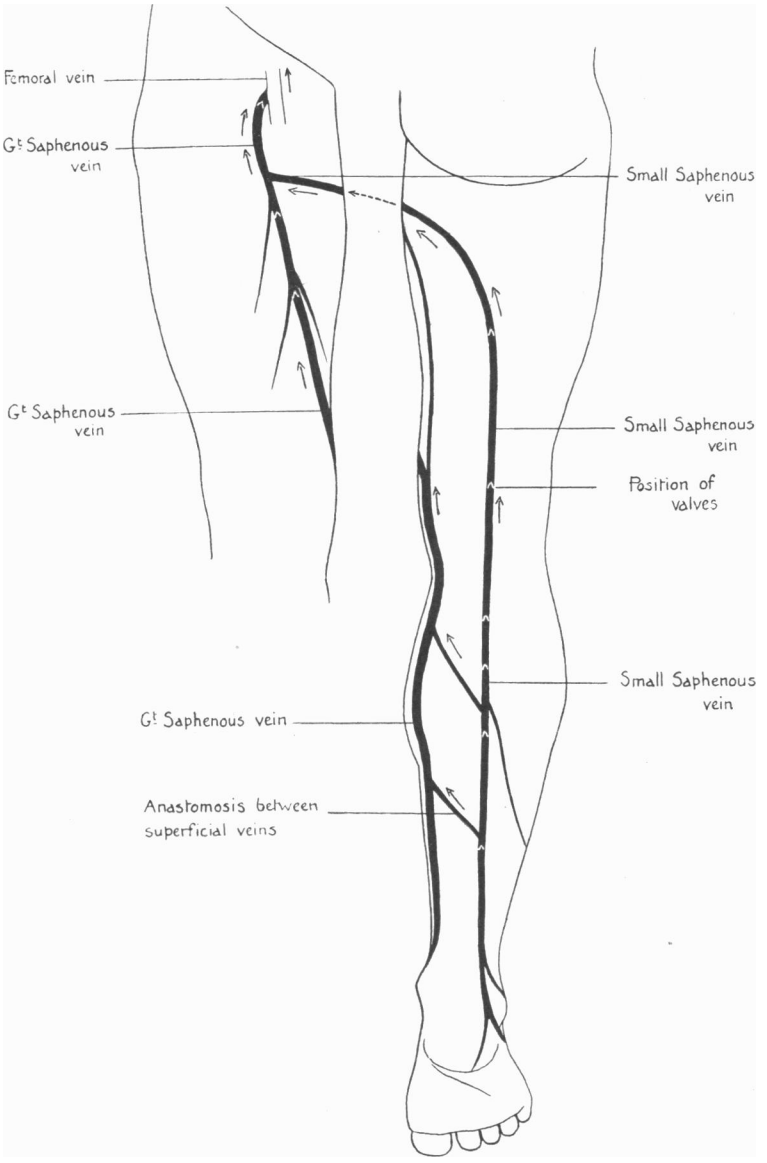

Fig. 2. High termination of the small saphenous vein.

It is therefore important to regard the great saphenous vein in man as the main superficial channel for the venous blood of the lower extremity.

As regards the anastomoses of the small saphenous vein with the deep

venous trunks of the leg, they are extremely scanty and only develop when the small saphenous vein terminates on the leg (about 10 per cent.), not reaching the popliteal space (fig. 3). This anastomosis when present is found in the lower half of the leg, and connects the small saphenous with the venae comitantes of the peroneal artery, the anastomotic channel passing close to the fibula. The usual arrangement is that the deep anastomoses of the great saphenous serve both great and small saphenous veins.

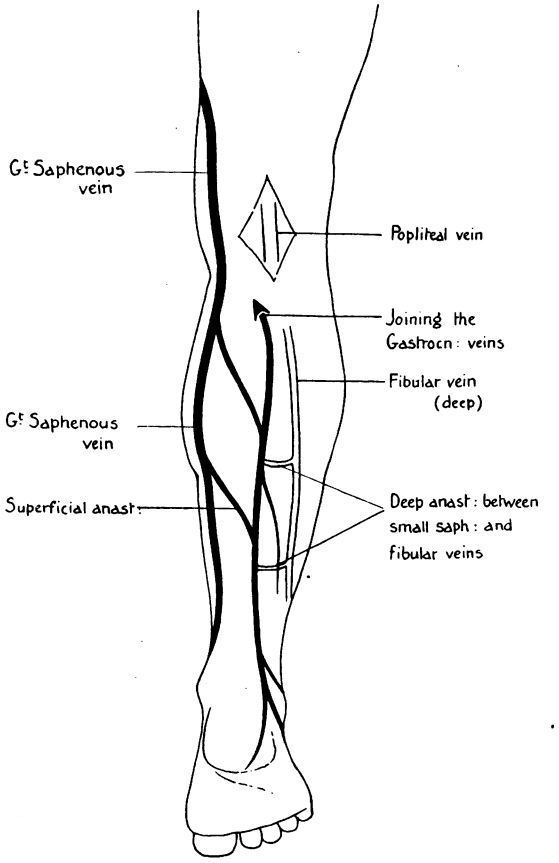

Fig. 3. Low termination of the small saphenous vein.

(*f*) *The number and arrangement of the valves* of the small saphenous vein depend on and correspond to the number of afferent tributaries and in general vary from 4 to 13. The average number is 8. This agrees pretty well with other observers (Houzé, Hovelacque, Cunningham).

Perhaps it would be interesting to consider the number of valves in regard to age and sex. The following two tables summarise the relations:

Table I. *The number of valves in the small saphenous vein in the leg at various ages*

Number of valves	4	5	6	7	8	9	10	11	12	13	Total number of cases
Age 18–29	1	1	3	4	5	4	2	2	—	—	22
30–40	—	2	1	3	2	2	1	2	1	—	14
41–50	—	—	1	3	3	1	—	3	1	1	13
51–60	—	—	2	1	7	1	—	3	—	—	14
61–70	—	1	2	2	7	4	—	2	—	—	18
71–88	—	—	—	—	1	—	1	1	—	1	4
Number of cases	1	4	9	13	25	12	4	13	2	2	85

It follows from this table that in 60 per cent. of cases the number of valves is between 7 and 11, and that this number is independent of the age of the subject.

Table II. *The relation of sex to the number of valves in the small saphenous vein of the leg*

The number of valves	Males	Females	Total
4	1	—	1
5	2	2	4
6	6	3	9
7	8	5	13
8	12	13	25
9	9	3	12
10	3	1	4
11	7	6	13
12	2	—	2
13	2	—	2

The tables show that sex and age have no influence on the number of valves. We see that in one case, aged 23, the number of valves is only 4, and in an old man, aged 88, the number even reaches 13. It is true that with age some valves are slightly degenerated and the walls of the veins are thickened.

The distance between the particular valves varies greatly—from $\frac{1}{2}$ or $\frac{3}{4}$ cm. to 10–12 cm., and occasionally even 15 cm. The average distance is 4·4 cm. (according to Houzé, 4 cm.); the most frequent distance is 2 cm. to 5 cm.

As examples of the usual arrangement of the valves on the leg we give the following formula (going from below upwards), showing the intervals between valves in cm.:

$$5 : 10 : 4 : 2 : 5 : 10 : 5.$$
$$3 : 5 : 5 : 2\tfrac{1}{2} : 4 : 5 : 6 : 10 : 6 : 1.$$

The valves are without exception bicuspid and are situated just below the junction of the tributaries.

(*g*) *The modes of ending of the small saphenous vein.* The variability in the terminations can be expressed as follows:

(1) Most frequently (in 57·3 per cent.: 71 cases) the small saphenous vein joins the popliteal vein in the region of the knee-joint.

(2) In 33 per cent. (41 cases) or in one-third of the cases (according to Giacomini—who investigated 51 limbs—in 26 per cent.): the *high* termination

on the thigh, either into posterior deep femoral veins or into great saphenous vein.

(3) In 9·7 per cent. (12 cases): the *low* termination in the leg, not reaching the popliteal region but ending in the great saphenous vein, or in the deep veins of the leg (usually gastrocnemial veins). These variations are quite independent of sex.

Type (1) may be subdivided into two groups:

(i) In this the small saphenous vein ends exclusively in the popliteal vein. Three-fourths of type (1) belong to this group (42 per cent. = 52 cases). The small saphenous vein forms an arch which enters the popliteal vein on an average at 4·5 cm. above the knee-joint, just below the middle of the popliteal space. The beginning of the arch receives the small superficial posterior vein of the thigh (v. cut. fem. post. of Meyer, v. femoro-poplitea of Hyrtl). This vein begins in the upper or middle third of the thigh, and runs under the deep fascia on the medial side of the small sciatic nerve. In addition, this vein often communicates with the deep posterior muscular veins of the thigh. In rare cases (3) it runs round the medial side of the middle of the thigh towards the great saphenous vein. In 10 cases that posterior superficial vein of the thigh is lacking completely.

(ii) Frequency 15·3 per cent. (19 cases). Small saphenous divides into two branches of equal size. One branch joins the popliteal vein and the other continues the course of the small saphenous vein on the thigh, and ascends to join the great saphenous vein (see fig. 1). The junction with the popliteal vein is at the same level as in the previous group (at 4 cm. above the knee-joint), while the junction with the great saphenous vein is on an average 32 cm. above the knee-joint—in the upper third of the thigh. The branch to the great saphenous vein runs first in the middle line of the posterior surface of the thigh (under the deep fascia), and at a level on an average of about 16 cm. above the knee-joint bends obliquely round to the medial side to join the great saphenous vein.

The relation of the arch of the small saphenous vein to the tibial nerve may be of importance since it explains the obstinate pain in the leg when the veins are varicose. The vein is always intimately connected with the nerve, lying either on the lateral (most often—in 54·5 per cent.) or on the medial side (in 40·9 per cent.). According to Giacomini (10) the first relation occurs in 57·5 per cent., and the second in 42·5 per cent. Occasionally the tibial nerve with its sural branch crosses underneath the arch (in 4·6 per cent.).

Type (2). *High termination* of the small saphenous vein either into the deep posterior veins of the thigh or into the great saphenous vein takes place in 33 per cent. of cases (in 41 cases).

Three varieties can be distinguished:

(i) In 13·7 per cent. (17 cases) it passes entirely into the deep posterior veins of the thigh (the lower perforating veins, especially the third, and the sciatic veins). The level of junction—on an average is about 12 cm. above the knee-joint.

We note the close relation in this variety to the great sciatic nerve, the vein being most frequently on its lateral side. This is important, as varicose veins in this situation may press on the nerve and so cause pain (sciatica).

This termination in the majority of cases takes place through the short head of the biceps muscle. In 2 of these cases a small anatomotic vein was found between the small saphenous and popliteal veins at the level of the knee-joint; and in 4 cases a small cutaneous vein draining the posterior aspect of the thigh joined the main trunk before its entry into the deep posterior veins of the thigh.

The valves present in the femoral portion of the small saphenous vein allow blood to pass in an upward direction. According to Hochstetter (13) the terminal femoral portion in that case is the remains of the primitive sciatic vein which usually disappears.

(ii) In 6·4 per cent. (8 cases), according to Giacomini in 6 per cent. the small saphenous vein divides at the level of the middle of the popliteal space into two branches of nearly equal size, of which one passes to the deep posterior veins of the thigh and the other into the great saphenous vein.

The junction with the deep posterior veins takes place on an average 10 cm. above the knee-joint and that with the great saphenous vein at 26 cm. (range 12–36 cm.) above the knee-joint. The first 16 cm. of its course is subfascial and the last 10 cm. subcutaneous.

The first part is straight in its course, accompanying the small sciatic nerve, while the second part is oblique in direction towards its point of entry into great saphenous vein.

(iii) In 12·9 per cent., according to Giacomini, 14 per cent. This variety occurred in 16 cases of which 6 were males and 10 females, and 6 on the left side of the leg and 10 on the right. This condition was symmetrical in half of the cases (see fig. 2).

We see in this type that all the blood carried by the small saphenous vein drains into the great saphenous vein, and the junction takes place on an average of 31 cm. above the knee-joint, i.e. in the upper third of the thigh, the range being from 18–36 cm. In 4 cases the small saphenous vein was connected with the popliteal vein by small twigs in the region of the knee-joint; and in 6 cases at a higher level are found connections between the small saphenous and the inter- or intra-muscular veins of the thigh.

We find that the direction of the small saphenous vein in the thigh is exactly to the course taken by it in variety (ii)—i.e. that the change from a purely vertical to an oblique path takes place about 16 cm. above the knee-joint, i.e. somewhat below the middle of the thigh. The relations to the deep fascia of the thigh are precisely similar. The diameter of the crural and femoral portion in this variety are found to be the same—namely 2–3 mm. Usually the size increases in the uppermost part owing to the many superficial tributaries on the thigh. The few (2–4) but constant valves in the femoral portion of the small saphenous vein allow the blood to flow upwards only. The dis-

tances between the valves in this portion of the vein are in cm.: 7 : 14 : 10 or 14 : 13 : 2.

The femoral portion of the vein was called "ramus anastomoticus" by Cruveilhier and was regarded by this author as a venous anomaly. In recent text-books it is called "accessory saphenous vein."

Type (3) occurred in 9·7 per cent. (12 cases) (see fig. 3). Here the small saphenous vein terminated in other veins below the knee-joint, either in the great saphenous (variety (i)) or in the deep veins of the calf (variety (ii)).

(i) The frequency of this variety occurs in 8·1 per cent. of legs (10 cases). The junction with the great saphenous vein was variable, but generally takes place in the upper half of the leg and only in 2 cases 1 cm. above the knee-joint. In 4 cases a small cutaneous vein found running down from the popliteal space to join the small saphenous may be regarded as the usual upward continuation of the main trunk; while in 6 cases this apparently small continuation of the small saphenous joined some muscular veins about 5 cm. above the knee-joint.

(ii) The frequency here was 1·6 per cent. (2 cases) (fig. 3). It joined the intragastrocnemial veins, either in the upper third or at junction of middle and upper thirds. As above, the small cutaneous vein passed in a downward direction to join the small saphenous.

To elucidate the varieties described above, the following table is appended:

Type	Variety i %	Variety ii %	Variety iii %	%	Total cases
1	42·0	15·3	—	57·3	71
2	13·7	6·4	12·9	33·0	41
3	8·1	1·6	—	9·7	12

In one-third of cases the small saphenous vein joins directly the great saphenous vein. In two-thirds of cases it joins the deep veins of the lower extremity, either in the popliteal region (most often) or in the thigh or occasionally on the leg. It is very important to note that in 12·9 per cent. of cases (according to Giacomini in 14 per cent.) the small saphenous vein is entirely drained into the great saphenous vein in the upper third of the thigh without any other important connections.

These cases in which the small saphenous vein joins the great saphenous vein, and in 13 per cent. cases this is the main mode of termination of the small saphenous vein, have a direct bearing on the production of varicosity, for there accumulates in the great saphenous vein all the superficial venous drainage of the lower extremity and hence the superficial veins must sustain an increased pressure.

That portion of the small saphenous vein passing into the great saphenous vein in the thigh has only 2–3–4 valves. These are bicuspid and so placed that the current of blood must flow from the small to the great saphenous vein.

Furthermore, this vein in its lower half ascends vertically on the posterior surface of the thigh while in the upper half of its course it winds obliquely

round the medial aspect of the thigh to enter the great saphenous vein almost at right angles (see diagram).

II. *Great Saphenous Vein.*

There is a great difference of opinion as to the direction of the blood-current between the superficial and deep veins.

The majority of investigators suggest that the blood flows from the superficial to deep veins (Spalteholz, Braune, Delbet, Homans, Houzé, Le Dentu, Luschka). Henle and Klotz, however, suppose it possible that the blood may flow in either direction. Theile and Twyman believe that the current flows from the deep to the superficial veins.

I think that the following experiments show that the arrangement of the superficial vein and its anastomoses with deep veins are designed to avoid an accumulation of blood in the great saphenous vein which is the main superficial venous trunk. When the great saphenous vein was injected from above, all the deep veins of leg and thigh were filled with the injection-mass. Ligation of the popliteal vein did not alter the distribution of the injection. On the other hand, all the superficial veins below the level of the main anastomotic channel contain no injected mass.

When the injection is made from below both the superficial and deep veins were filled.

The arrangement of anastomotic channels are by transverse vessels situated:

(*a*) Just below the knee-joint, two or three in number, connecting with the inferior medial articular, superior genicular and intra-articular.

(*b*) At the junction of the middle and superior thirds of the leg—usually two in number, connecting the small saphenous vein with both the medial gastrocnemial and posterior tibial. This latter is the most important channel; it is large enough, the usual diameter being $1\frac{1}{2}$–2 mm., to convey all the superficial blood to the deep vessels, and its course is close to the tibia through the muscular attachments (fig. 1).

(*c*) At the junction of the middle and distal thirds of the leg. This vessel is small and connected to the posterior tibial vein.

(*d*) The anastomoses between the great saphenous vein and the deep veins on the thigh are scarce and usually in the middle of the thigh.

DISCUSSION

As the result of the anatomical investigation of the distribution of the veins and the direction of the flow of injected mass, I can confirm absolutely the experimental conclusions of Luschka, Giacomini, Ledderhose and others that the current of the blood flows from the superficial to the deep veins. Magnus found experimentally that 90 per cent. of injected fluid flowed by way of the deep veins and only 10 per cent. by way of the great saphenous vein. It is noteworthy that the calibre of the great saphenous vein is often less at its termination than in the lower part of the leg.

In every case it has been shown that after ligation of the femoral vein the

main return takes place not by the superficial veins but by the way of intramuscular veins and alongside the great sciatic nerve, eventually to the internal iliac vein (Trzebinski, Karpinski, Müller). From the point of view of development and comparative anatomy this return along the sciatic region is interesting.

From embryology we know that the small saphenous vein represents the post-axial vein of the hind limb bud; it is the first vein to appear and originally opens into the internal iliac through the sciatic and gluteal veins. The subsequent transformation into a short vein opening into the popliteal vein may be an adaptation to the elongation and relative rigidity of the hind limb. This abbreviation of the post-axial vein of the lower extremity is the main difference in the venous system of the fore and hind limbs.

Comparative anatomy seems to indicate that the termination of the small saphenous vein into the popliteal vein is an adaptation peculiar to higher mammals including man.

In animals other than man varicose disease never occurs. They have usually only one superficial vein well developed, namely the small saphenous, the great saphenous being much smaller than it is in man and ending in the lower half of the thigh.

The small saphenous vein in apes and horses ends in the popliteal vein in the region of the knee, while the great saphenous vein ends by joining the femoral vein under cover of the sartorius in the lower half of the thigh. In the horse the posterior vein of the thigh serves to connect the small saphenous vein with the sciatic vein (Chauveau) and is especially well developed in this animal. From the dissections we have made it would appear that in the lower animals the small saphenous ascends to a higher level along the posterior aspect of the thigh.

The factors making for varicosis are:

1. The height of the column of blood. The average length of the great saphenous vein is 85 cm.
2. The thinness of the walls of the vein and the lack of muscular support.
3. The possible variations in the anatomical course of the small saphenous vein and its anastomotic channels.

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