Part III

Anatomy and surgical approaches

Anatomy of the Arteries of the Lower Limbs

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Arteria Femoralis, Femoral Artery

A. femoralis follows on from the external iliac artery and extends from the inguinal ligament to the ring of the adductor muscles, beyond which it takes the name of the popliteal artery.

The femoral artery proceeds vertically and slightly obliquely inwards and backwards in the anteromedial region of the thigh, with artery flowing movement in the upper third, when the thigh is flexed, and rectilinear when the thigh is extended.

At its origin it has artery diameter of 9-10 millimeters, diminishing in caliber after serving one large collateral artery, the deep femoral artery (Figure 1).

Observations. – In the initial tract the femoral artery is found in the *lacuna vasorum* and it occupies the right angle of this; it corresponds in front with the inguinal ligament, behind the pubic insertion of the pectineus muscle and to the Cooper ligament, laterally to the ileopectinal ligament, which separates it from the ileopsoas muscle and from the femoral nerve, medially to the femoral vein.

In the initial tract the femoral artery flows into the Scarpa triangle, contained in the prismatic interstice; it is covered by the superficial sheet of the fascia lata of the cribrous fascia, that closes the prismatic interstice in front, and by the tegument.

It rests, with the interposition of the deep sheet of the fascia lata, which forms the posterior wall of the prismatic interstice, on the ileopsoas muscle, near the back angle, placed between this muscle and the pectineus muscle and is occupied by the femoral vein; the ileopsoas muscle separates the artery from the head of the femur and from the articulatory capsule.

When it leaves the Scarpa triangle, the artery, contained with the satellite vein in the sheath of the femoral vessels, it flows for a long tract behind the sartorius muscle, which crosses it obliquely from above to below and from outside to inside, and rests on the duct formed by the vastus medialis of the femoral quadriceps and the long adductor muscles.

In its final tract, the artery is contained in the canal of the adductors and in relation to its walls, represented by the aponeurosis of the vastus medialis muscle of the quadriceps, by the adductor magnus and by the fibrous lamina, which closes in front the duct contained between the two muscles.

In correspondence with the ring of the adductors, the artery is situated immediately close to the femur. In the initial tract and along the Scarpa triangle the vein is placed medially with respect to the artery, so that it then passes back gradually to leave from the apex of the triangle and terminate in a posterior position in the canal of the adductors.

The femoral nerve is placed in the groin lateral to the artery, and is separated from it by fibre of the psoas muscle and the ileopectineal fascia. The saphenous nerve accompanies the artery for the whole of its length, draining out from the canal of the adductors from an orifice in the medial wall of the canal, together with the supreme artery of the knee. In the lower tract the deep branch of the accessory nerve of the saphenous accompanies the artery.

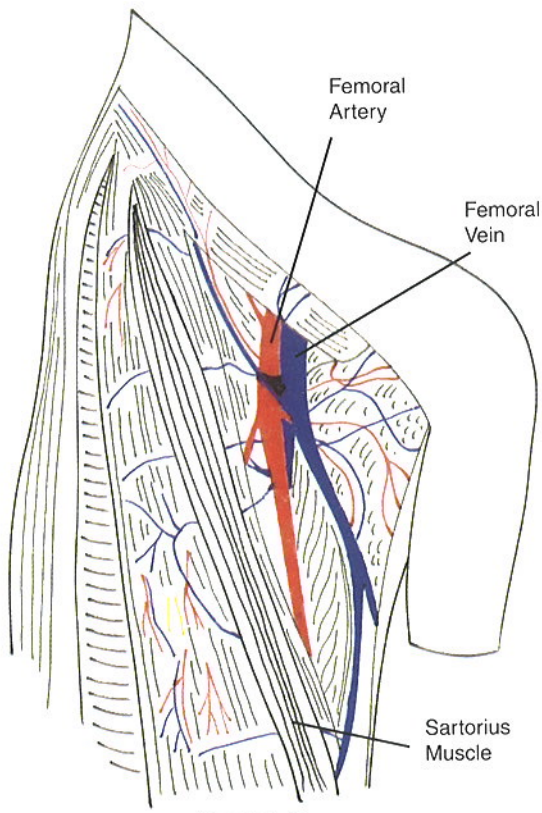


FIGURE 1
Vessels and Nerves of Scarpa Triangle

From Critical Lower Limb Ischemia Edited by R Bartolucci, L Battaglia, V D'Andrea, E De Antoni ©2002

Collateral Branches of the Femoral Artery

The femoral artery supplies the following ramifications: superficial epigastric artery, superficial circumflex iliac artery, external pudendal arteries, deep femoral artery, muscular branches, supreme artery of the knee.

I. *A. epigastrica superficialis.* It originates in the trunk of the femoral artery, 1 cm below the inguinal ligament, together with the superficial iliac circumflex artery; it perforates the sickle-form margin, crosses the inguinal ligament and passes up towards the umbilicus. It supplies branches of the inguinal lymphonodes, the skin and the oblique external muscle of the abdomen. It anastomoses with the superficial branches of the inferior epigastric artery.

II. *A. circumflexa ilium superficialis.* It originates in the trunk of the femoral artery immediately below the superficial epigastric artery; it becomes subcutaneous and flows laterally towards the superior anterior iliac spine, where it terminates with anastomoses with the deep circumflex iliac artery. It supplies branches of the inguinal lymphonodes, to the skin and to the near muscles.

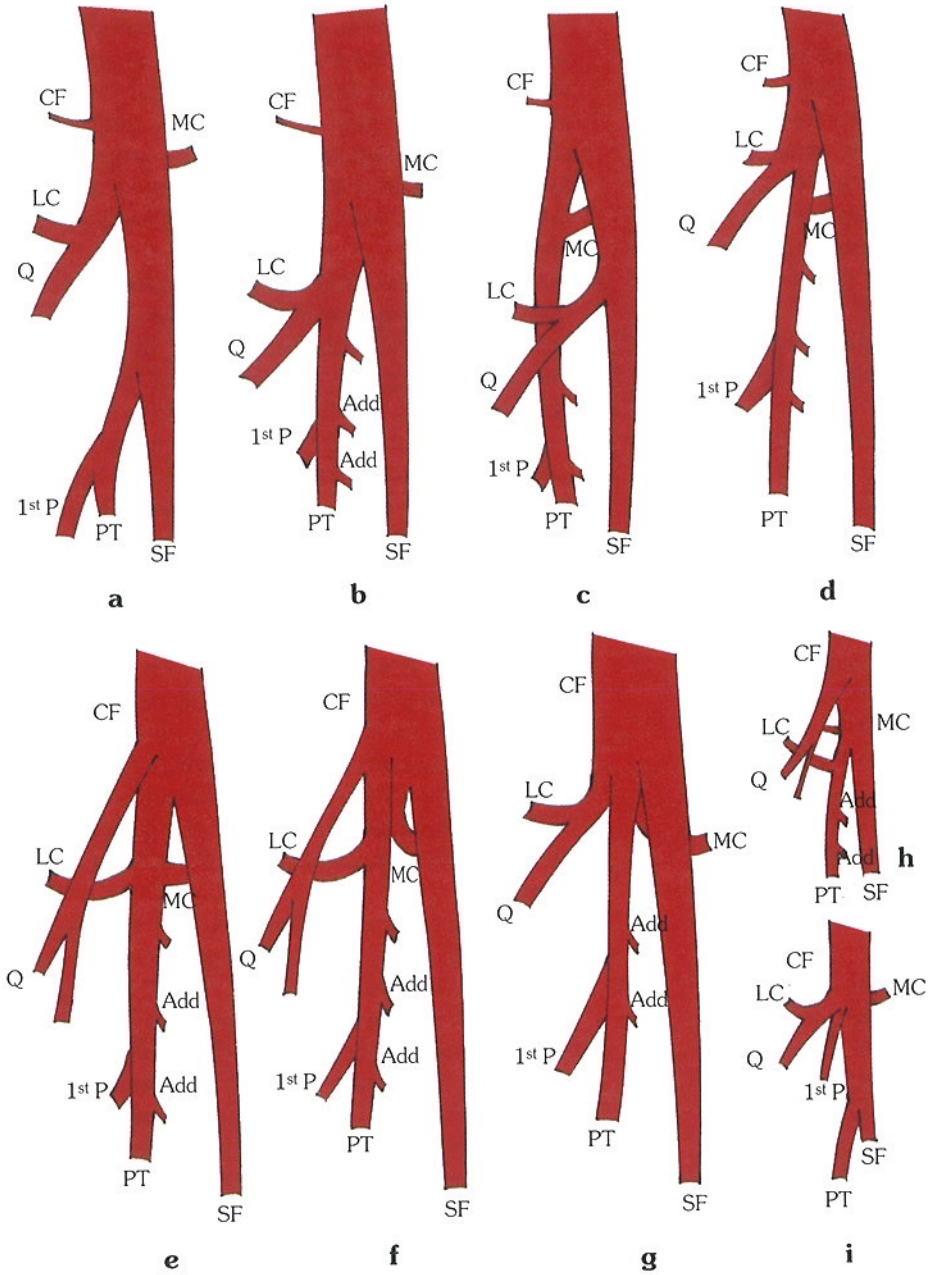
III. *Aa. pudendae externae.* Divided into superior and inferior, they can have originated from a common trunk.
   a) *A. pudenda superior externa.* They originate from the femoral artery immediately below the inguinal ligament, they perforate the fibrous fascia and become subcutaneous. It is divided into an ascending branch (for the inguinal ganglions and for the skin of the pubic region) and into a descending branch which is distributed in the male at the scrotum and at the tegument of the penis (*scrotalis anteriores*), and in the female in the labia majora (*labiales anteriores*).
   b) *A. pudenda inferior externa.* In the first tract of its flow it is subfascial, at a level which is lower than the superior external pudendal artery, and it crosses the anterior face of the femoral vein. It is distributed at the scrotum and at the labia majora.

The external pudendal arteries are anastomosed among one another and with those on the opposite side, with the external spermatic artery, a branch of the inferior epigastric, with cutaneous branches of the obturatory artery, with the artery of the perineum, and with the dorsal artery of the penis, terminal branches of the internal pudendal artery.

IV. *Rami inguinales.* Small branches which are distributed at the inguinal lymphonodes.

V. *A. profunda femoris* (Figure 2). It is the principal vessel of the thigh. It originates in the posterior face of the femoral artery of the Scarpa triangle, 4 cm below the inguinal ligament. It is of considerable calibre, and for some authors it is described as a branch of bifurcation of the above-mentioned trunk. The deep femoral artery descends in the thigh and flows in the first tract behind and external to the femoral artery, to then take up position behind it. It is found attached firstly to the ileopsoas and pectineus muscles, and then it insinuates itself into the interstice between the adductor longus muscle and the adductor brevis and magnus muscles near their intersection at the femur. It is separated from the vein and from the femoral artery and from the adductor longus muscle. Along its flow it supplies numerous branches, decreasing rapidly in calibre and terminating by perforating the adductor magnus muscle, approximately at the union of the medium third with the distal third of the thigh, with the name of third perforating artery. The deep femoral artery is accompanied by the deep femoral vein.

The deep femoral artery (DFA) is one of the two terminal branches of the common femoral artery, arising from its postero-lateral aspect, generally at a median distance of 4.4 cm below the inguinal ligament. From its origin, it proceeds caudally on a gradual, postero-lateral course towards the linea aspera, behind the third distal of the femur. Although this vessel is the primary source of blood supply to the thigh muscles, it also serves as the entrance and exit to an extensive collateral network through a series of branches. The lateral and medial circumflex femoral arteries, arising from the first centimeters or two of the DFA, have multiple connections through the circumflex femoral branches to the gluteal and perineal arteries proximally to receive inflow from the iliac vessels. The more distal perforating branches have variable origins, and their ramifications form an arcade to protect with the genicular and recurrent tibial arteries around the knee to fill patent segments of the popliteal-tibial network to supply the leg and foot. Based on these unique anatomic relationships, the DFA might be describes as the "back door to the leg", an alternative channel that runs parallel to the occluded superficial femoral artery (SFA), with the potential to vascularise the distal portion of the extremity. The DFA can be subdivided into three segments, each relevant to surgical exposure. The proximal section extends to the origin of the lateral circumflex artery, the middle section reaches to the second perforating branch, and the distal extends from the second perforating branch to the artery, superficial final division. The proximal segment lies in Scarpa's triangle, where it dips behind the lateral circumflex femoral vein, which must be divided to achieve adequate surgical exposure of the DFA at this level. The middle and distal segments lie posterior to the sartorius muscle, which must be retracted medially or, more often, laterally to expose the DFA.



LC = Lateral Circumflex Artery
Q = Quadricipital Artery
MC = Medial Circumflex Artery
Add = Adductores Arteries

1st P = 1st Perforant Artery
PT = Perforant Trunk
SF = Superficial Femoral Artery
CF = Common Femoral Artery

FIGURE 2

Varieties of Deep Femoral Artery (Williams Classification)

a. hight origin of lateral circumflex and quadricipital artery and low origin, at the level of superficial femoral artery, of perforating branches
b. usual disposition: deep femoral artery divides in lateral circumflex and quadricipital artery and perforating branches
c. lateral circumflex and quadricipital artery origin from the superficial femoral artery
d. hight division of the common femoral artery: medial circumflex artery origins from the deep femoral artery
e. hight division of the common femoral artery with separated origin of the lateral circumflex and quadricipital artery
f. more or less low division of the common femoral artery with trifurcation of quadricipital perforators and middle circumflex artery
g. trifurcation of the deep femoral artery: low or high division of the common femoral artery with more or less short trunk of deep femoral artery
h.i. other types

The distal segment runs beneath the adductor longus muscle, which is either incised or retracted anterolaterally for access.

The branches which the deep femoral artery supplies are the medial circumflex and lateral circumflex arteries of the femur, the perforating arteries and the muscle branches.

a) *A. circumflexa femoris medialis.* It takes its origin from the internal and posterior part of the deep femoral artery, near its origin, directs itself medially towards the femoral vessels and divides into a superficial branch and a deep one.

Ramus superficialis, which is fine, continues medially and downwards, before the pectineal muscle, between the adductor brevis and longus muscles, and is distributed in these muscles.

Ramus profundus, which is larger, enters deeply between the ileopsoas and the pectineus muscles

moves concavely along a curve above and outside, which passes around the anterior part of the femur's cervix; it exits below the external obturatorius muscle, on the back face of the rectus femoris, and here it spreads out into terminal branches. Along its course it supplies: muscular branches for the pectineus muscles, the adductor brevis and longus muscles and the external obturatorius muscles; these muscles are anastomosed with those of the obturatory artery and of the lateral circumflex artery of the femur;
periosteum and osteal branches for the cervix of the femur and for the area around the acetabulum;
an articulatory branch, which is anastomosed with a branch of the obturatory artery, penetrates into the articulation of the hip through the incisure of the acetabulum and is distributed to the fat of the acetabulum cavity and to the synovial membrane.
The terminal branches of the deep branch of the medial circumflex artery are divided into ascending and descending. The ascending branch passes up between the quadriceps femoris muscle and cervix of the femur as far as the trochanter cavity; it distributes branches to the cervix of the femur, to the articulatory capsule, to the muscles of the area (gemellus muscles, obturatorius, quadriceps femoris) it is anastomosed with the ischiatic artery, with the gluteus artery, and with the first perforating artery.

b) *A. circumflexa femoris lateralis*. It is the most voluminous of the branches of the deep femoral artery. It is born on the external face of this, close to its origin. It moves laterally, lying on the ileopsoas, and on the vastus of the quadriceps, covered by the sartorius and rectus femoris muscles. Successively it enters in depth into the trochanter insertions of the vastus lateralis muscle, moves around the great trochanter and terminates in the posterior face of the thigh, being anastomosed with the gluteal, ischiatic and the circumflex medial arteries. Among the branches that supply the muscles with which they enter into relationship, the ascending and the descending branch must be noted.
Ramus ascendens bears upwards and sidewards, under the tensor fascia lata muscle of the bathing this muscle and the anterior sections of the gluteus minimus and medius muscles; it is anastomosed with the terminal branches of the gluteal and deep circumflex iliaca arteries.
Ramus descendens (artery of the femoral quadriceps), which is very voluminous, bears downwards and sidewards, below the rectus muscle of the femur, between the vastus intermedius and lateralis, almost as far as the knee. It is distributed at the quadriceps femoris muscle and is anastomosed with the inferior perforating arteries and with the lateral superior articulatory artery, a collateral branch of the popliteal artery. It supplies branches to the skin in the external region of the thigh.

c) *Aa. perforantes*. Generally they are three in number and they are of considerable size. Each bears backwards, passing through the adductor muscles, through the orifices limited by the aponeurotic arches, which are found along the insertions of these muscles at the linea aspera of the femur. When they reach to the posterior fascia of the thigh they divide into an ascending branch and a descending one, by means of which they anastomose with one another creating a system which, higher up, connects with the branches of the ischiatic and medial circumflex arteries of the femur and, lower down, with an ascending branch of the popliteal artery. This system represents in the hematic circulation of the inferior extremities a collateral route which rejoins the ischiatic artery with the deep femoral artery, as well as the hypogastric artery to the femoral, and can substitute this vessel when it becomes obliterated.
Before passing through the adductor muscles the perforating arteries supply branches to these muscles, to the vastus medialis muscle and to the periosteum of the femur. When they reach the first posterior region of the thigh, they supply numerous branches for the semitendinosus, semimembranosus, biceps muscles and for the ischial nerve and a series of cutaneous branches that emerge along the posterior part of the lateral intermuscular septum and bathe the skin of the lateral and posterior face of the thigh. Each artery supplies besides a lateral branch which moves transversally, passes round the posterior part of the femur and empties into the vastus muscle.
The first perforating artery, which is more voluminous, perforates the adductors at the inferior margin of the pectineus muscle and supplies some branches at the gluteus maximus muscle.
The second perforating artery, the thinnest one, runs below the inferior margin of the adductor brevis muscle; the nourishing artery of the femur arises from this artery.
The third perforating artery is represented by the termination of the trunk of the deep femoral

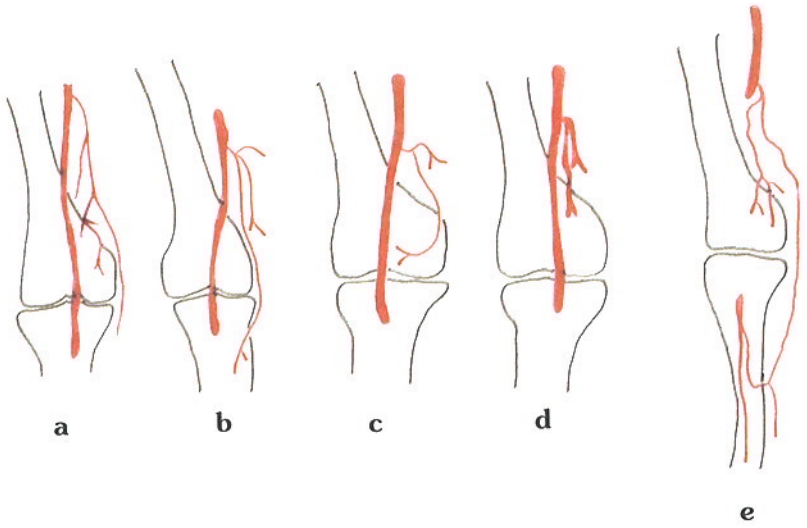


FIGURE 3
Patra Classification of Descending Artery of the Knee
a: DAK with muscular and articular branches and saphenous branch
b: DAK without muscular and articular branches
c: DAK without saphenous branch
d: filiform and unclassificable DAK
e: DAK with saphenous branch anastomosing the recurrent internal tibial artery

artery, perforates the adductor magnus muscle above the ring of the adductors (hiatus tendineus).

d) *Rami muscolares.* They are various in number and origin. They flow to the vastus medialis muscle and to adductor muscles.

VI) *Rami muscolares.* They are small branches that originate directly from the femoral at various heights, and move to the small veins (sartorius, adductors, vastus medialis) and to the skin.

VII) *A. genus suprema* (great anastomotic artery, DAK Descending Artery of the Knee) (Figure 3). It is a voluminous branch that parts from the terminal tract of the femoral artery in the adductor canal or in the vicinity of this, and it divides into two branches: the superficial and deep. The superficial branch (saphenous branch) perforates the anterior wall of the adductor canal, moves downwards and emerges under the posterior margin of the sartorius muscle; it is a satellite of the saphenous nerve, with which it descends into the leg to then branch out at the teguments of the upper and medial parts of the leg. It contributes to the constitution of the articulatory network of the knee with one of its branches, which turns together with the rotula branch of the saphenous nerve, under the patella. The deep branch descends to the front of the tendon of the adductor magnus; it provides branches for the vastus medialis and the vastus intermedialis muscles and terminates on the medial condyle of the femur, to which it provides periostic and bone branches, on the part corresponding to the articulatory capsule of the knee; it is anastomosed with the supero-medial articulatory artery.

Varieties of the Femoral Artery and its Branches

Very rarely it can happen that the principal artery of the lower limb is:

A. ischiatica that descends in the posterior part of the thigh and takes the name of the popliteal artery, maintaining in this way in the adult the primitive disposition, that is observed during development and which is permanent in other vertebrates (amphibians, reptiles) (Figure 4). In these cases the exterior iliac artery terminates at the bend of the groin or continues in a femoral

FIGURE 4
Pillet Classification of the Sciatic Artery:

Type 1: corresponds to rare cases in which the persistent sciatic artery is complete and the femoral system is normal;

Type 2: comprises more frequent cases in which the persistent sciatic artery is complete and the femoral system incomplete;

Type 3: includes cases with incomplete persistent sciatic artery in the superior tract;

Type 4: includes cases with incomplete persistent sciatic artery in the inferior tract.

artery which is more slender than usual, which fades out in the thigh. The femoral artery can double out into two trunks, which, after a more or less lengthy course, join again. The external iliac artery is described as converting at its termination into the femoral artery, the deep femoral artery and into the artery of the quadriceps.

The femoral artery can give origin to branches that normally arise from the external iliac and the hypogastric artery, as the inferior hypogastric artery, the deep iliac circumflex artery and a obturatory artery, more rarely, the ileolumbar artery and the dorsal artery of the penis. It can also supply branches that usually proceed from the deep femoral artery, like the circumflex arteries of the femur and the artery of the quadriceps. Finally, branches accessory to the normal ones can arise from this.

As regards the branches of the femoral artery, the superficial epigastric artery, if it is more developed than usual, can provide branches to the thigh and from this can arise the medial circumflex artery of the femur. The external pudendal arteries can originate from the deep femoral artery, can become one or increase in number, rarely can one of these supply the dorsum of the penis, and they can participate in the irrigation of the testicle.

The deep femoral artery itself can originate from the femoral artery higher or lower than normal, from 1 cm up to 7-8 cm or more from the inguinal ligament. It can also arise from the external iliac artery. It can detach itself laterally or in front, in which case it crosses the anterior face of femoral vein to regain its normal position. It can be missing, and its collaterals can spring directly from the femoral artery. It sometimes supplies the inferior epigastric, superficial epigastric, obturatory, deep circumflex iliac arteries, the dorsum of the penis, external pudendal and some accessory perforating arteries. The circumflex arteries of the femur can arise from the femoral artery instead of from the deep femoral artery, especially if this has a low origin. The supreme artery of the knee can be missing or arise from the popliteal artery. The saphenous branch can assume considerable development and become a supernumerary of the femoral artery (great saphenous artery), which can be followed as far as the medial malleolus (reproducing, in this way, in man, a disposition which is native to many mammals).

The persistent sciatic artery can be present in two forms:

Complete form: it ensures the vascularisation of the lower limb on its own or at least in a dominating way and it does not diminish in calibre from the iliac to the popliteal artery.

Incomplete form: when there is an interruption in the tract between the internal iliac artery and the popliteal or when it vascularises the popliteal through collateral branches.

Arteria Poplitea, Popliteal Artery

A. poplitea follows on from the femoral and is situated in the posterior part of the knee, extending to the termination of the adductor canal until the tendon arch of the soleus muscle. When it has passed below this, it divides into its terminal branches: the anterior and posterior tibial arteries. In the first part of its course it presents a slight obliquity outwards, then descends vertically, behind the major axis of the popliteal cavity. In the extended leg it is rectilinear, when the leg is flexed it becomes flexuous (Figure 5).

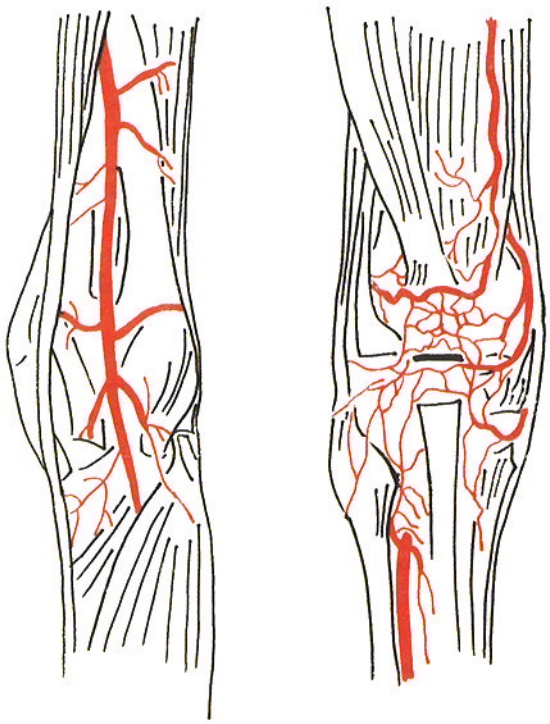


FIGURE 5
Popliteal Artery and its Branches

Observations. – At its source it is covered by a semimembranosus muscle and it lies between this and the medial face of the femur. It appears successively in the depth of the popliteal cavity, between the semimembranosus and biceps muscles. It corresponds in front to the popliteal plane of the femur, from which it is separated by a great layer of fat, and, lower down, to the articulatory capsule of the knee. It is hidden finally under the gastrocnemius and plantaris muscles and flows between these and the popliteus muscle. The popliteal artery is accompanied by the popliteal vein. The two vessels flow in a thick common sheath and adhere one to the other.

The vein is situated behind and external to the artery, but when it arrives at the interstice of the gastrocnemius muscle it is on its internal face: in this latter tract it is not rarely double, and then the two veins flank the artery. More superficially than these two vessels, below the fascia, runs the tibial nerve, which, at the beginning, is separated from the vessels by a thick layer of fat, then it moves close to these and attaches itself to their posterior face. For most of its course, the tibial nerve runs behind and external to the vein; only at the interstice of the gastrocnemius, where the vein is moved medially, does the nerve correspond directly behind the artery. The three organs of the neurovascular bundle, during the passage through the popliteal cavity, are placed as follows: more superficially and more laterally the nerve, then the vein and more deeply and medially the artery.

Collateral Branches of the Popliteal Artery

The collateral branches of the popliteal artery and the articulatory arteries of the knee (lateral superior, medial superior, middle, lateral inferior, and medial inferior) and the muscle branches among which the sural or twin arteries merit special attention.

I. *A. genus superior lateralis.* This arises from the anterior face of the popliteal artery, a little below the superior margin of the femoral condyle; it moves obliquely upwards and outwards; it passes between the biceps femoris muscle, and moves around this bone to which it is directly attached, 2-3 cm above the condyle. At this level, after supplying several branches of adjoining organs, it divides into a superior or deep branch and an inferior or superficial branch. The superior branch inserts itself below the vastus intermedius and is distributed in this muscle, anastomosing with the branches of the supreme artery of the knee; it also bathes the periostium. The lower branch is attached to the articulatory capsule and bears towards the lateral margin of the patella, descends along this, and anastomoses with a branch of the lateral inferior articulatory artery; with its ramifications it contributes to forming the articulatory network of the knee.

II. *A. genus superior medialis.* It arises from the anterior face of the popliteal artery, above the superior margin of the femoral condyle; it moves medially and passes around behind in front of the femur, a little above the condyle, passing between the bone and the semitendinosus and semimembranosus muscles, and then between the femur and the tendon of the adductor magnus. It divides into two orders of branches, deep and superficial. The deep branches insert themselves below the vastus medialis muscle and are distributed to this muscle and to the periosteum, anastomosing with the corresponding of the supreme artery of the knee.

III. *A. genus media.* It is a small branch, often doubled, which arises from the anterior face of the popliteal artery (or from the lateral superior articulatory artery) at the level of the articulatory interline of the knee. It perforates the articulatory capsule above the oblique popliteal ligament and is distributed to the crossed ligaments, to the synovial folds, to the fat of the inter-condylar incisure and to the epiphyses of the femur and the tibia.

IV. *A. genus inferior lateralis.* It arises on the anterior face of the popliteal artery, below the articulatory interline; it moves inwards, running firstly behind the popliteal muscle, in front of the gemellus externus and plantaris muscles, then passes around the lateral meniscus of the articulation covered by the fibular collateral ligament and by the biceps tendon. It reaches the anterior part of the articulation, and ends in terminal branches. During its flow it supplies numerous branches to the muscles, to the fibrous capsule of the knee, to the fibular collateral ligament and to the tibio-fibula articulation. The terminal branches are anastomosed with those of the other articulatory arteries and of the anterior tibial recurrent artery, and contribute in forming the articulatory network of the knee.

V. *A. genus inferior medialis.* It arises on the anterior face of the popliteal artery, above the articulatory interline; it moves downwards and medially, following the superior margin of the popliteus muscle, it reaches the medial part of the articulation of the knee, inserts itself between the tibia and the tibial collateral ligament and it ends in terminal branches. It supplies branches of the popliteus muscle and to the posterior part of the fibrous capsule and is anastomosed with those of the other articulatory arteries and contribute in forming the articulatory network of the knee.

VI. *Rete articolare genus.* The superior and interior articulatory arteries, ramifying and anastomosing with the anterior part of the knee, form a network to which flow the supreme artery of the knee, the anterior tibial artery and the descending branch of the lateral circumflex artery of the femur. This network is partly deeply set on the bones and on the ligaments of the articulation and is made up of vessels which are relatively larger and with a thicker mesh; and partly it is situated superficially, under the skin, on the tendon and quadriceps femoris muscle, on the patella and on the patellar ligament, and it is made up of thinner vessels and with a more open mesh. The articulatory network of the knee bathes the articulatory heads, the patella, the fibrous capsule, the ligaments and the tendons, and the teguments of the region.

VII. *Rami muscolares. Aa. surales* (twin arteries). They are the most important, by virtue of their volume, among the many branches they detach themselves from the popliteal artery through the muscles of the popliteal region. Generally in groups of two, they arise, sometimes by means of a common trunk, from the popliteal artery above the articulatory interline of the knee. They bear obliquely downwards towards the corresponding sural muscle and they end in superficial and deep branches. The superficial branches descend on the posterior face of the surals as far as towards the origin of the Achilles tendon. One of these accompanies the small saphenous vein, and supplies the sural muscles and the skin. The deep branches penetrate into the gemellus muscles and are distributed to these muscles, to the popliteus and soleus muscles and to the plantaris muscle.

Varieties of the Popliteal Artery and of its Collateral Branches

(Figure 6)

In very rare cases, the popliteal artery con be in the continuation of the ischiatic artery, when the femoral artery is of reduced volume and fades out in the thigh. In this case it flows behind the popliteal vein. The same inversion of relationships has also been observed in some cases of normal origin of the popliteal artery. It is described as dividing into two trunks, which after a small track reunite. An aberrant case has also been described, which, after detaching itself from this, flows into the posterior tibial artery. The division of the popliteal artery into its terminal branches can occur higher than normal (up to inside the intercondylar cavity) or lower (down to as far as the middle part of the leg). Instead of

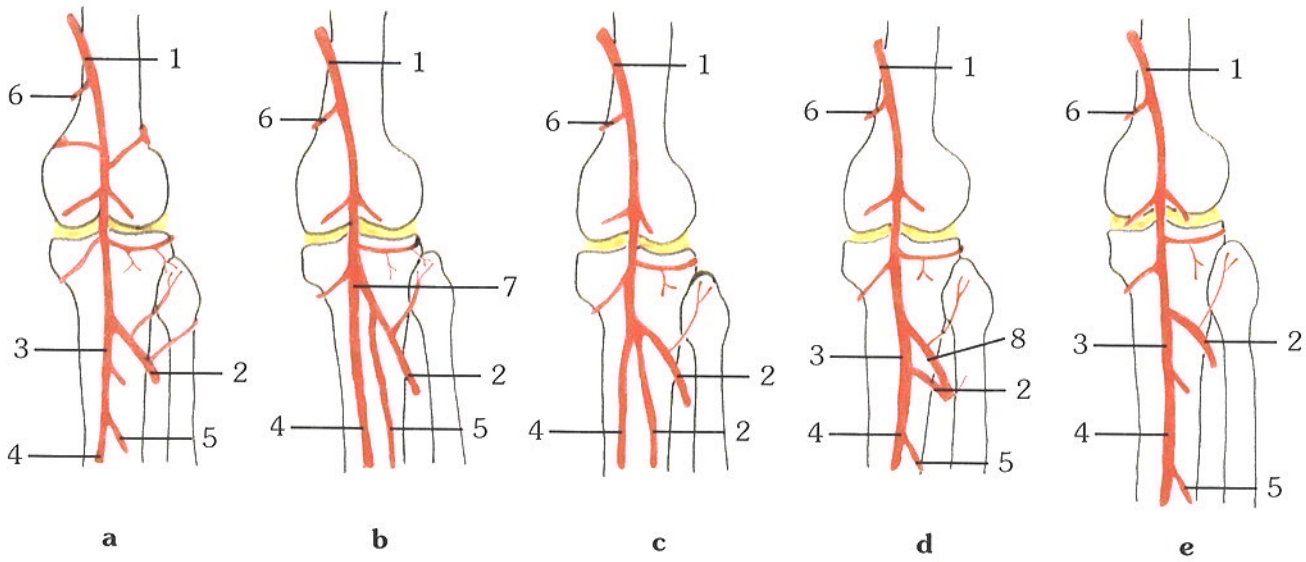


FIGURE 6

Popliteal Artery. Varietes of its Branches.

a. common type
b. tibio peroneal trunk
c. the three arteries of the leg divide at the same level
d. anastomosis of the deep anterior tibial artery and tibio peroneal trunk
e. too long tibio peroneal trunk

1 = Popliteal Artery
2 = Anterior Tibial Artery
3 = Tibio Peroneal Trunk usually comprises by Posterior Tibial Artery
4 = Posterior Tibial Artery
5 = Peroneal Artery
6 = Superior Artery of the Knee
7 = Anterior Tibio Peroneal Trunk
8 = Anastomosis to Anterior Tibial Artery

bifurcating into the anterior tibial artery and the posterior tibial artery, it can terminate in the anterior tibial artery and in the peroneal artery, missing the posterior tibial artery, or into the posterior tibial artery and the peroneal, which supplies the anterior tibial artery, or even into the posterior tibial artery, the peroneal and the anterior tibial artery. The popliteal artery can give birth to the supreme artery of the knee, to an accessory posterior tibial artery, and to a small saphenous artery which is overdeveloped in an abnormal way and which descend as far as the lateral malleolus.

The articulatory arteries can be double; some can be missing and be substituted by another vessel. Not rarely does the middle articulatory artery derive from one of the other articulatory arteries.

Terminal Branches of the Popliteal Artery

A. tibialis posterior. The posterior tibial artery, the most voluminous of the two branches resulting from the bifurcation of the popliteal artery, flow along the posterior part of the leg, between the superficial and deep muscles. It arises below the ring of the soleus muscle and corresponds at its origin in the interval between the tibia and the fibula. After a short tract, it bears obliquely inwards, coming close to the medial margin of the leg, to then descend vertically towards the tibia. It arrives at the medial douche of the heel, where, at the level of a line which joins the point of the medial malleolus to the tuberosity of the heel, it terminates dividing into the medial and lateral plantar arteries (Figure 7).

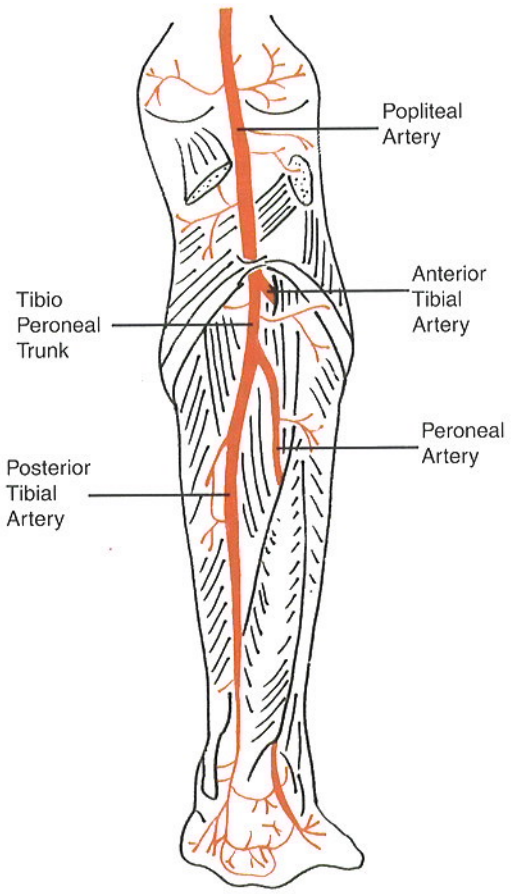


FIGURE 7
Arteries of Lower Leg

Observations. – In the superior part the artery is situated in depth, covered by the triceps muscle of the sura (gastrocnemius and soleus). In the inferior third of the leg it flows medially with respect to the calcanear tendon and remains covered by a double fascia and by the tegument. It remains superficial along the calcanear groove, where it is covered by a superficial sheet of lacinatus ligament, and it is situated between the tendon of the flexor digitorum longus muscle, which keep them in front, and the tendon of the flexor hallucis longus muscle, which keeps them behind. At the termination it is placed under the origin of the abductor hallucis muscle. In front the artery corresponds to posterior tibial and the flexor hallucis longus muscles, and it is held applied to these by the deep sheet of the fascia of the leg. At its inferior extremity it lies directly on the tibia and on the tibio-astragalic articulation.

The posterior tibial artery is flanked by two satellite veins. The tibial nerve flows first medially to the artery, and then crosses it behind and places itself laterally to it.

Observations. – Along its course it supplies a certain number of muscular and cutaneous branches, and successively the recurrent medial tibial artery, the fibular branch, the peroneal artery, the nourishing artery of the tibia, the medial posterior malleolar artery, the communicating branch, the medial calcaneal branches. It terminates finally dividing in the medial and lateral plantar arteries.

Collateral Branches of the Posterior Tibial Artery

(Figure 8)

I. *Rami muscolares.* In variable number, they originate at differing height and are distributed at the tibialis posterior and the long flexor digitorum longus muscles; one or two, of considerable calibre, at the medial part of the soleus muscle.

II. *Rami cutanei.* Two or three, of small calibre, bathe the skin on the medial face of the leg.

III. *A. recurrens tibialis medialis.* This arises in the superior tract of the posterior tibial artery, passes around the medial margin of the tibia, perforates the insertions of the soleus muscle and is distributed at the periosteum of the higher part of the medial face of the tibia and at the corresponding covering. It is anastomosed with the inferior medial articulatory artery of the knee and with the recurrent anterior tibial artery.

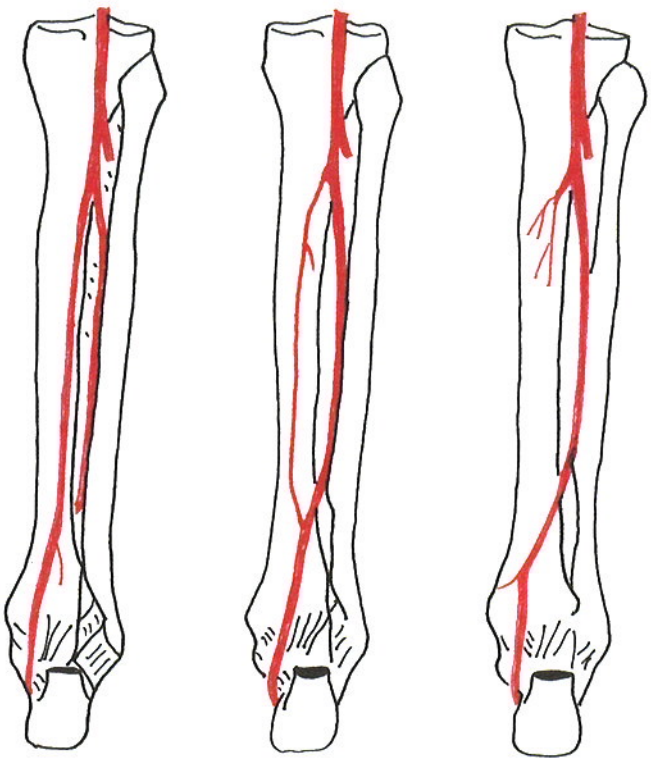


FIGURE 8

Variations of the Posterior Tibial and Peroneal Arteries

a. posterior tibial artery runs distally at posterior surface of the tibia and ends with the plantar arteries

b. posterior tibial artery is only weakly developed and its region of irrigation is taken over by peroneal artery (phylogenetically older)

c. posterior tibial artery is completely absent

IV. *Ramus circumflexus fibulae.* This arises from the initial tract of the posterior tibial artery, moves laterally towards the cortex of the fibula and it distributed to the soleus and peroneus longus muscles.

V. *A. peronea.* For calibre and length it is the most conspicuous of the branches of the posterior tibial artery. It arises at 2-3 cm from the origin of this vessel, moves firstly obliquely downwards and outside towards the fibula, then descends vertically in the leg until it joins behind the talocrural articulation, where it ends in the lateral calcaneal branches. It is placed deeply, on the same plane as the artery from which it derives. At its origin and in its first section it lies on the tibialis posterior muscle and is covered by a deep sheet of the leg fascia and by the soleus muscle; successively it flows between the tibialis posterior muscle and the flexor hallucis longus muscle on the medial face of the tibia, then it lies on the dorsal face of the interosseous membrane and finally, after supplying the perforating branch of the inferior extremity of the interosseal space and after reducing in calibre, it descends behind the tibiofibular syndesmosis and behind the lateral malleolus. The peroneal artery is accompanied by two satellite veins and by the branch that the tibial nerve sends to the flexor hallucis longus muscle.

It supplies along its course the following collateral branches:

a) numerous *rami muscolares* that are distributed in the soleus, tibialis posterior, the flexor hallucis longus, and the peroneus anterior muscles.

b) *A. nutrititia fibulae*, that penetrates into the channel of this bone.

c) *Ramus perforans.* This arises in the inferior part of the leg, perforates the interosseous membrane a little above the tibiofibular syndesmosis, as far as the external side of the tarsus. It communicates with the lateral anterior malleolar artery, a branch of the anterior tibial, and with the lateral artery of the tarsus, contributing in forming the lateral malleolar network, which occupies the region of the malleolus, and of the calcaneal network. Its ramifications go to the inferior extremity of the fibula, to the articulations of the foot, and to the peroneus anterior muscle. The calibre of this artery is inversely proportional to that of the anterior tibial.

d) *A. malleolaris posterior medialis.* It flows attached to the fibula, it moves to the face of the malleolus and contributes in forming the lateral malleolar network.

e) *Ramus communicans.* Completes the communicating branch of the posterior tibial artery.

The terminal branches of the peroneal artery, lateral calcaneal branches, branch out on the external face and on the posterior part of the heel; they are anastomosed with the perforating branch, with the lateral malleolar arteries, with the lateral tarsal artery, and with the medial calcaneal branches. They contribute in forming the calcaneal network.

VI. *A. nutrititia tibiae.* It is the most voluminous of all the nutritive arteries of the bones. It detaches itself from the initial tract of the posterior tibial artery, moves downwards and inwards, supplies branches to the neighboring muscles and penetrates into the nutritive foramen of the tibia. When it joins the midolar channel, it turns into an ascending branch and a descending branch.

VII. *A. malleolaris posterior medialis.* It arises behind the malleolus of the tibia, passes under the tendons of the flexor digitorum longus muscles and the posterior tibial artery, arrives on the medial face of the malleolus and contributes with the branches coming

from the anterior tibial artery and from the dorsum of the foot in the formation of the tibial malleolar network.

VIII. *Ramus communicans.* It arises from the posterior tibial a little above the malleolus, passes under the tendon of the flexor hallucis longus muscle and is anastomosed with a similar branch of the peroneal artery. It supplies small branches to the tibia.

IX. *Rami calcanei mediales.* Two or three, usually very voluminous, arise from the posterior tibial artery, when this arrives in the calcaneal groove; they move downwards and inwards towards the region of the calcaneus and contribute to the formation of the calcaneal network together with the lateral calcaneal branches of the peroneal artery. This supplies the skin, the adipose cushion of the heel, the periosteum of the calcaneus and the muscles and the tendons that reach their head at the calcaneal tuberosity.

Terminal Branches of the Posterior Tibial Artery (Figure 9)

I. *A. plantaris medialis.* This is a medial branch of the bifurcation of the posterior tibial artery. It is a thin vessel, to be considered as a collateral branch of the lateral plantar artery, the principal artery of the foot. It bears forward contained in the lodge that is to found between the two sheets of the laciniated ligament, and here it divides into a deep branch and a superficial branch.
Ramus profundus is covered in its initial part by the abductor hallucis muscle, then it flows in a groove between this and the flexor digitorum brevis muscle. It moves forward, reaches the head of the first metatarsal bone and ends flowing into the first plantar metatarsal artery or into the medial plantar artery. It supplies numerous collateral branches that flow to the abductor hallucis muscle and flexor hallucis brevis muscle and flexor digitorum brevis muscle, to the teguments of the medial margin of the foot, to the bones and to the articulations.
Ramus superficialis, considered as the prolongation of the trunk of the medial plantar, crosses the deep face of the abductor hallucis and emerges above muscle, following the superior margin of it as far as the metatarso-phalangeal articulation of the first toe. It supplies numerous branches at the abductor and at the tegument of the medial margin of the foot and is anastomosed with branches of the dorsal artery of the foot.

II. *A. plantaris lateralis.* It is more voluminous than the medial plantar and it is considered as the direct continuation in the foot of the posterior tibial. It moves at first forwards and outwards towards the base of the fifth metatarsal bone, here it changes direction turning obliquely inwards and crosses the sole of the foot creating a curve with the anterior cavity, the plantar arch; It terminates in the interval between the bases of the first and second metatarsal bone where it joins with the deep branch of the dorsal artery of the foot. At its origin the lateral plantar artery is placed between the two sheets of the laciniated ligament. It flows forward on the quadratus plantae muscle, covered first by the abductor hallucis muscle and then by the flexor digitorum brevis muscle; in proximity with the fifth metatarsal bone it becomes more superficial, lying in the interval between the quadratus plantae muscle and the flexor digiti minimi brevis, covered by the plantar aponeurosis. At the level of the plantar arch it is situated deeply, below the base of the metatarsal bone and the interosseous bones and of the interosseous muscles, between these and the oblique head of the adductor hallucis muscle. The lateral plantar artery is accompanied by two satellite veins and by the lateral plantar nerve.

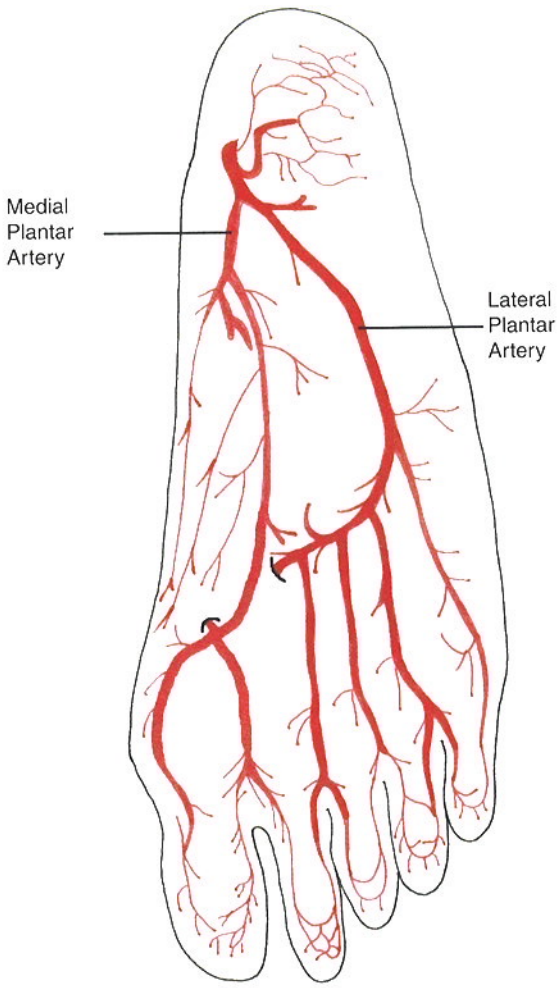


FIGURE 9
Arteries of the Plantar Surface of the Foot

Branches. In its course to the fifth metatarsal bone the plantar artery supplies:

a) numerous muscular branches with which it enters into relationship;
b) branches to the skeleton of the region that it covers, especially at the calcaneus, and it is anastomosed with the calcaneal arteries;
c) cutaneous branches that emerge in the furrow between the middle portion and the lateral one of the plantar aponeurosis and others that re-ascend on the lateral margin of the foot and which are anastomosed with ramifications of the dorsal artery of the foot.

From the plantar arch arise (Figure 10):

a) small posterior branches and they flow from the cavity of the arch and are taken in the tarso-metatarsal articulations and in the fibrous sheath of the peroneus longus lateral muscle;
b) small inferior branches and these move to the abductor hallucis oblique;
c) posterior perforating branches, three in number, they cross the posterior extremity of the last intermetatarsal spaces, between the original fasciae of the interosseous dorsalis muscles and, when they reach the dorsum of the foot, they enter into corresponding metatarsal dorsal arteries, at their origin. The perforating branches can arise from the plantar metatarsal arteries instead of from the plantar arch; they can enter dorsally instead of in the dorsal metatarsal arteries, in the accurate artery. The anastomosis of the termination of the lateral plantar artery with the deep plantar branch of the dorsalis pedis artery, across the posterior extremity of the first intermetatarsal space, represents the first posterior perforating branch.
d) Fifth plantar metatarsal artery. It arises from the lateral plantar artery; at the posterior extremity of the fifth metatarsal it changes direction to form the plantar arch. It moves forwards along the medial margin of the abductor digiti minimi muscle, reaching and following the external side of this. It supplies numerous branches to the muscles of the external plantar region and to the corresponding covering. Along the toe it can take on the name of the digital plantar artery.
e) Second, third and fourth plantar metatarsal artery. From the plantar arch they move forwards flowing in the corresponding intermetatarsal space, attached to the interosseal muscles. At the level of the head of the metatarsal bones they are between the transverse ligament of the heads and the transverse head of the adductor hallucis muscle. They supply branches to the interosseous

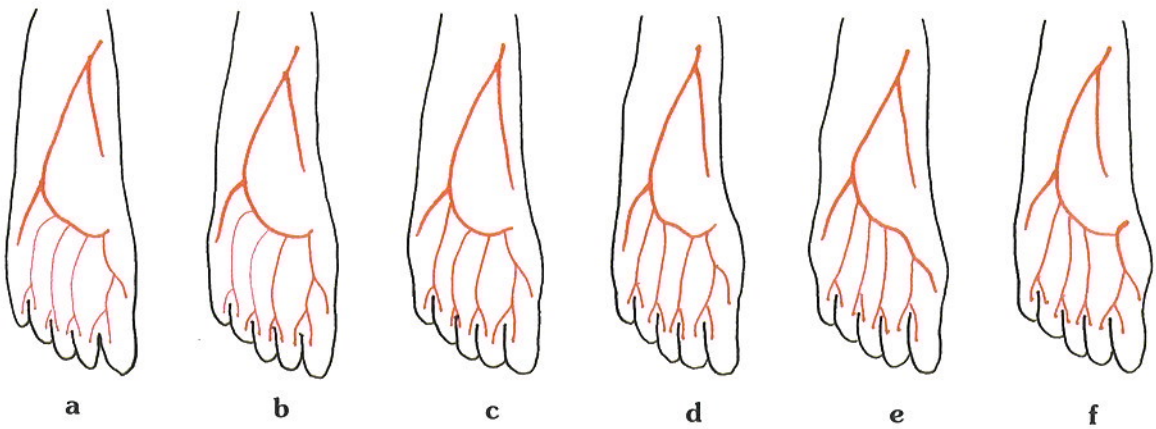


FIGURE 10

Arterial Variations of the Sole

a. the four plantar metatarsal arteries obtain blood from the deep plantar branch of the dorsalis pedis artery (27%)
b. the plantar arch is formed entirely from the deep plantar branch of the dorsalis pedis artery (26%)
c. the fourth plantar artery is supplied by the deep branch of the lateral plantar artery (19%)
d. the third and fourth plantar metatarsal arteries are supplied with blood by the deep branch of the lateral plantar artery (13%)
e. the four plantar metatarsal arteries arise from the plantar arch , which is formed by just deep branch of the lateral plantar artery (7%)
f. the second to fourth plantar metatarsal arteries arise from the plantar arch, whereas the first metatarsal artery originates from the deep plantar branch of the dorsalis pedis artery (6%)

muscles and from the adductor hallucis muscle. They terminate at the level of the first phalanxes dividing each into two plantar digital arteries, and run through the opposite margin of the pressurial face of the two contiguous toes. At the level of their bifurcation they receive the anterior perforating branches of the dorsal metatarsal arteries. The digital arteries send out branches they reunite with one another on the axial line of the plantar and dorsal face of the toe, to begin from the first inter-phalangeal articulation. When they arrive at the final phalanx they are anastomosed at the arch; from this originate small branches that move in part to the digital pulp and in part into the subungul region.

f) First plantar metatarsal artery. It arises from the termination of the lateral plantar artery, it bears forwards into the first intermetatarsal space and divides into two branches: a medial branch, which emerges between the two heads of the flexor hallucis brevis muscle, flows into the medial plantar artery; a lateral branch, that moves laterally around the metatarseo-phalangeal articulation of the first toe, gushes into the first dorsal metatarsal artery, where this terminates dividing in the trunk of the plantar digital arteries of the first toe and the medial plantar digital of the second toe. The plantar metatarsal artery first functions in a way that is analogous to the other plantar metatarsal arteries and supplies the plantar digital arteries for the first toe and for the medial margin of the second toe.

Arteria Tibialis Anterior, Anterior Tibial Artery
(Figure 11)

A. tibialis anterior, an anterior branch of bifurcation of the popliteal artery, extends from below the tendinous arch of the soleus muscle up to the level of the crossed ligament of the leg, passing behind which it changes name to become the dorsal artery of the foot. It arise in the posterior lodge of the foot, exits into the anterior lodge, passing through the eyelet between the tibia and the fibula above, above the interosseous membrane, with an oblique direction downwards and backwards. Above it is in contact with the medial face of the head of the fibula, descending it gradually nears the tibia, in the inferior quarter of the leg in rests on the anterior face of this bone.

Observations. – In the short initial tract of the posterior lodge of the leg, the artery passes across the origins of the tibialis posterior muscle. When it emerges from the anterior lodge, it is attached for most of its course to the interosseous membrane, to which it is united through fibrous tracts. In the final portion it lies above the tibia. It is covered by the anterior muscles of the leg; first it corresponds at the interstice between the tibialis anterior and the extensor digitorum longus muscles, then at the interstice between this and the extensor hallucis longus muscle. From the moment when these selfsame muscles in descending become thinner and finally are reduced to tendons, the artery becomes gradually less deep. In the inferior quarter of the leg the artery, having become superficial, and attached to the anterior face of the tibia and the tendon of the extensor hallucis longus muscle crosses it in front and at an acute angle. At the level of the termination of the crossed ligament, the artery, covered by deep layers of the upper medial arm of this ligament, rests on the capsule of the tibiotarsal articulation.

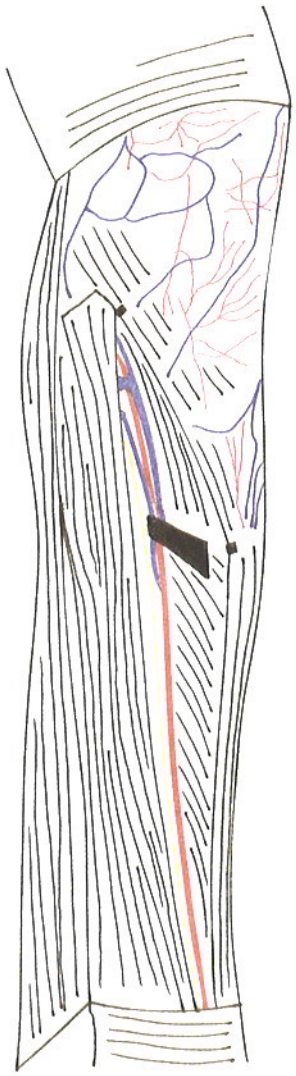


FIGURE 11
Anterior Tibial Artery

The anterior tibial artery is accompanied by two satellite veins which exchange between one another numerous transversal anastomoses. The deep peroneal nerve descends from the lateral contour of the cervix of the fibula, approaches the artery placing itself to the side, crosses it in front and in the inferior part of the leg flows at the medial side of this.

Ramifications. – Along its course the anterior tibial artery supplies numerous muscular branches, the posterior tibial recurrent artery, the anterior tibial recurrent artery, the lateral anterior malleolar and the medial anterior malleolar arteries. Often it gives rise to a fibular branch, that can also arise from the popliteal artery.

I. *Rami muscolares.* They are very numerous, arise at different heights and are distributed above all in the anterior muscles of the leg. They send out some branches through the interosseous membrane to the tibialis posterior muscle and to other branches in front of the skin.

II. *A. recurrens tibialis posterior.* This is a small branch that arises from the initial tract of anterior tibial artery; it bears upwards under the popliteus muscle towards the tibio-fibular articulation, where it terminates, It supplies small branches to the popliteus muscle and is anastomosed with the inferior articulatory arteries of the knee, and is often absent.

III. *A. recurrens tibialis anterior.* This arises from the anterior tibial artery, as soon as this arrives in the anterior lodge of the leg. It moves upwards, in front and medially, applied to the anterior face of the lateral condyle of the tibia and is covered by the tibialis anterior, providing branches to this muscle and to the bone. It emerges at the level of the tuberosity of the tibia and ends in its terminal branches, and contributes to the formation of the articulatory network of the knee.

IV. *A. malleolaris anterior lateralis.* This arises from the anterior tibial artery a little above the tibiotarsal articulation, moves laterally, passes below the tendons of the extensor digitorum longus and of the peroneus anterior muscles, arrives at the lateral posterior malleolus and descends vertically, terminating on the external side of the tarsus. It is anastomosed with the lateral posterior malleolar artery and with the perforating branch, both branches of the peroneal artery, and with the lateral tarsal artery, a branch of the dorsum of the foot. It contributes in forming the lateral malleolar network. Some of its ramifications go to the malleolus and to the skin which covers it, others to the tibio-fibular syndesmosis and to the tibio-tarsal articulation, still others, flowing under the tendons of the peroneus lateral muscles, reach the lateral superficies of the calcaneus and are distributed to this.

V. *A. malleolaris anterior medialis.* Thinner than the above, it arises a little above the tibio-tarsal articulation. It moves medially passing below the tendons of the extensor hallucis longus muscle and of the tibialis anterior muscle arriving at the anterior margin of the tibial malleolus, where it divides in a superficial branch, which is distributed at the superficies of the malleolus and at the skin which covers it, and in a deep branch for the tibio-tarsal articulation. It is anastomosed with the medial posterior malleolar artery, a branch of the posterior tibial, with the medial tarsal arteries, branches of the dorsum of the foot, and with branches of the medial plantar branch of the posterior tibial. In contributes in forming on the malleolus the medial malleolar network.

Dorsalis Pedis Artery

(Figure 12)

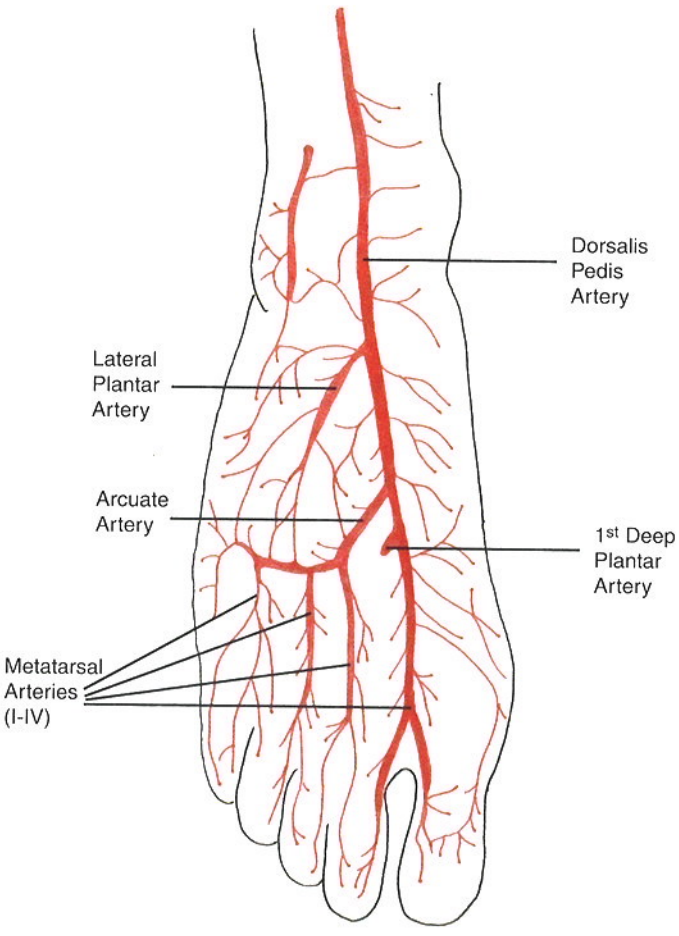


FIGURE 12
Dorsalis Pedis Artery

A. dorsales pedis is a vessel which is in the direct continuation of the anterior tibial artery. It begins at the level of the tibio-tarsal articulation, moves forwards and inwards, parallel to the axis of the foot, reaching the posterior extremity of the first intermetatarsal space. Here it terminates dividing into the dorsal metatarsal artery first, and then in the deep plantar branch, by means of which it is anastomosed to a full channel with the termination of the lateral plantar artery. The dorsal artery of the foot is of variable volume, inversely proportional to that of the lateral plantar artery and of the perforating branch of the peroneal artery.

Observations. – It is placed superficially, below the teguments, the superficial dorsal fascia and the fascia of the extensor digitorum brevis muscle. At its origin it is covered also by inferior medial arm of the crossed ligament of the leg. It rests on the bones of the tarsus and on their articulations. It flows in the interval between the tendon of the extensor hallucis longus muscle and that of the extensor digitorum longus; laterally it enters into relationship with the extensor digitorum brevis muscle which, at the termination of the artery, superimposes itself on this with the tendon of its medial ventricle, which crosses it obliquely from outside to inwards. The artery is accompanied by two satellite veins and by the medial branch of the termination of the deep peroneal nerve, which remain medial to it.

Ramifications. – The dorsalis pedis artery supplies along its course the medial tarsal arteries, the lateral tarsal artery and the arcuate. It terminates dividing into the dorsal metatarsal artery first and then into the deep plantar branch.

Collateral branches
(Figure 13)

I. *Aa. tarseae mediales.* They are two or three small branches that flow on the bones and on the ligaments of the tarsus and move towards the medial part of the foot, anastomosing with branches of the medial plantar artery.
II. *A. tarsea lateralis.* It arises from the dorsal artery of the foot at the level of the head of the astragalus and moves in front and laterally, attached to the bones and to the ligaments, covered by the extensor digitorum brevis muscle. It terminates above the cuboid, which are resolved into a line of branches which are anastomosed with the termination of the arcuate artery, the lateral plantar and with the perforating peroneal artery. They contribute with their ramifications to form, with the other arteries of the region, the dorsal network of the foot. They supply branches to the skeleton, to the extensor digitorum brevis muscle and to the covering.
III. *A. arcuata.* Among the collateral branches of the dorsum of the foot it is the most voluminous vessel. It arises at the termination of the dorsal artery of the foot and it moves laterally attached to the base of the metatarsal bones, forming a curve of anterior convexity; when it reaches the lateral margin of the foot it terminates anastomosing with a branch of the lateral tarsal artery and with the lateral plantar. It supplies along its concave margin branches that contribute to forming the dorsal network of the foot and give blood to the skeleton and to the extensor digitorum

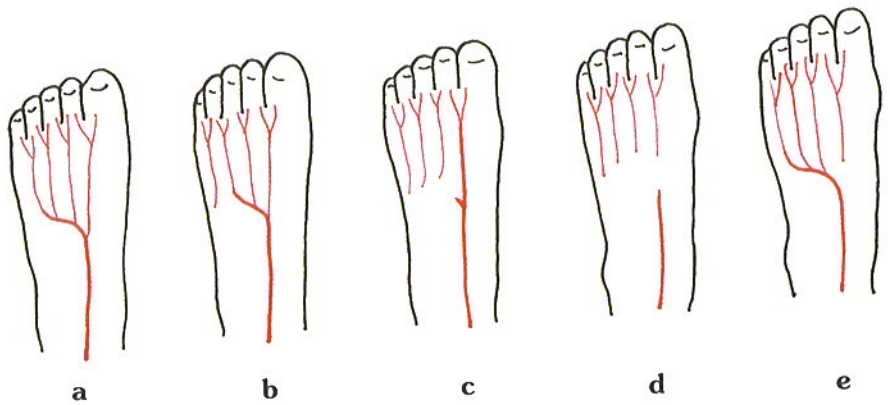


FIGURE 13
Arterial Variations of the Dorsum of the Foot
a. all dorsal metatarsal arteries arise from the dorsalis pedis artery (20%)
b. first of the three dorsal metatarsal arteries arises from the dorsalis pedis artery; the last metatarsal artery obtains its blood via a perforating branch of the sole (6%)
c. first dosal metatarsal artery alone represents the continuation of the dorsalis pedis artery , whereas the remaining metatarsal arteries obtain their inflow from the sole (40%)
d. all dorsal metatarsal arteries are supplied by plantar arteries (10%)
e. first dorsal metatarsal artery arises from a plantar artery, while the rest metatarsal arterial branches origine from the dorsalis pedis artery (5%)

brevis muscle. From it convexity originate the dorsal metatarsal arteries II-IV.

Aa. metatarseae dorsales II-IV. They move forwards and above, respectively, the II, III, and IV intermetatarsal space, resting on the dorsal interosseous muscles. When they arrive at the level of the metatarsal-phalangeal articulations each divides into two dorsal digital arteries, which course along the margin contiguous to the corresponding toes and provide small branches to the dorsum of the toes, not pressing on beyond the first phalangeal articulation. From the IV metatarsal artery (sometimes directly from the arcuate artery) there arises also lateral dorsal digital fine artery of the IV toe. At the level of the posterior extremity of the intermetatarsal space each dorsal metatarsal artery communicates with the plantar arch or with the corresponding metatarsal artery by means of a conspicuous posterior perforating branch, which crosses the interosseal space vertically. Each dorsal metatarsal artery, when it is about to bifurcate, communicates with the corresponding plantar metatarsal artery by means of an anterior perforating branch, generally thin and changeable.

Terminal branches

I. *A. metatarsea dorsales I.* It arises through division of the dorsal artery of the foot and moves forward and moves forward above the first metatarsal space, holding itself in the direction of the trunk from which it derives. It is more voluminous than the other dorsal metatarsal arteries and flows on the superior face of the dorsal interosseous muscle. At the level of the metatarsal-phalangeal articulation of the first toe it supplies two branches: one medial, which is the common trunk the dorsal digital arteries of the first toe, and one lateral, which is the medial digital artery of the second toe. Immediately after supplying these two branches it moves towards the plantar surface of the foot as an anterior perforating branch, receives the first plantar metatarsal artery and bifurcates into two terminal branches: one medial: one medial, which is the common trunk of the plantar digital arteries of the first toe, and one lateral, which is the medial plantar digital artery of the second toe.

The dorsal digital artery on the medial side of the first toe is often small and can be completely absent. Only in some cases are the first three plantar digital arteries given by the first plantar metatarsal artery; in this case the first dorsal metatarsal acts at its termination in the same way as the other similarly-named arteries, and the communication between this and the first plantar metatarsal artery acquires the character of an anterior perforating branch.

II. *Ramus plantaris profundus.* Immediately after its origin, by division of the dorsal artery of the foot, through the posterior extremity of the first intermetatarsal space, making its way between the two heads of the origin of the dorsal interosseous muscle, and after reaching the sole of the foot it is anastomosed with the termination of the lateral plantar artery, completing the plantar arch. It is comparable to the posterior perforating branches of the other intermetatarsal spaces.

Variations of the Terminal Branches of the Popliteal Artery

I. Variations of the posterior tibial artery. The posterior tibial artery can have a development which is less than normal and disappear in the leg, sometimes not far from its origin, or can be completely absent; in all these cases it is substituted by the peroneal artery, that acquires greater volume. It has been described as crossing the inferior part of the interosseous membrane and gushing into the anterior tibial artery. It can be very thin in its initial tract and can be reinforced at a certain point by one or two anastomotic branches coming from the peroneal artery. As supernumerary branches it can supply, through the interosseous membrane, an anastomotic branch through the anterior tibial and through the dorsum of the foot. One of these abnormal anterior can give origin to a part of the arteries of the dorsum of the foot. The peroneal artery can arise lower than normal, as far down as the middle third of the leg, or higher, even in the final tract of the popliteal artery. In the case of high division of this vessel, the peroneal artery can detach itself from the anterior tibial artery. Rarely is it thin, of short course, or absent, and it is substituted by other branches of the posterior tibial artery or the anterior tibial artery. More often it has a greater calibre than usual and can substitute the posterior tibial artery or the anterior tibial artery or both. The perforating branch of the peroneal artery can be missing and substituted by the lateral anterior malleolar artery, a branch of the anterior tibial artery. Sometimes it is voluminous to substitute for the small calibre of the anterior tibial artery in the lower part of the leg, and to take the place of the dorsal artery of the foot.

One can note antagonism and compensation between the respective development of the two plantar arteries. The medial plantar artery can be very thin and disappear in the flexor hallucis brevis muscle; if it has a greater volume than normal it supplies the first or even the first three plantar digital arteries. The lateral plantar artery can be so small that as to

not take part in constitution of the plantar arch, and in this case it is formed by the dorsal artery of the foot. On the contrary, it can be more voluminous than normal and supply, by means of perforating branches, most of the arteries of the dorsal region. There can be an anastomosis at the arch, placed between the plantar aponeurosis and the flexor digitorum brevis muscle, to the formation of which the medial plantar artery and a branch of the lateral plantar artery contribute. This superficial plantar arch, always little developed, is homologous with the superficial plantar arch; through its presence the type of the of the distribution of the arteries of the sole of the foot becomes similar to the type of distribution of the arteries in the palm of the hand. The normal absence of a superficial plantar arch and the fact that the arteries of the toes arise in the foot from the plantar arch placed deeply are in correlation with the use of the foot as an organ of support and of locomotion, which does not favor the development of the superficial vessels.

II. Variations of the anterior tibial artery. When the popliteal artery bifurcates prematurely, the anterior tibial artery in reaching the superior extremity of the interosseal space can pass in front of the popliteus muscle. The anterior tibial artery in order to re-emerge at the anterior face of the of the leg can contour the head of the fibula. Very rarely it flows in the lodge of the peroneus muscles and does not acquire its normal position in the lower part of the leg. The anterior tibial artery can be missing or reduced in varying ways; sometimes it disappears in the popliteus muscle and in the recurring anterior tibial artery; more often it terminates in the leg without continuing in the dorsum of the leg. It is substituted, according to the cases, by perforating branches of the posterior tibial artery or by the perforating branch of the peroneal artery.

The anterior recurrent tibial artery is often doubled. It can supply a branch which descends in the lodge of the peroneus muscles; when this branch acquires a considerable development there is the consistent anomaly in the course of the anterior tibial artery in the external lodge of the leg. The malleolar arteries present numerous variations in their origin and volume. When they are absent, they are substituted the medial by a branch of the posterior tibial artery, the lateral by the perforating branch of the peroneal artery.

III. Variations of the dorsal artery of the foot. The dorsal artery of the foot can be thinner than normal or can be missing when the anterior tibial artery has been reduced and it resolves on the dorsal face of the foot in branches through the region of the tarsus and of the metatarsus. In these cases the dorsal artery of the foot is substituted by the perforating branch of the peroneal artery, unusually voluminous. It must be remembered that there is frequently a conspicuous anastomosis between the perforating branch of the peroneal artery and the dorsal artery of the foot.

The lateral tarsal artery can be doubled.

The arcuate artery is very variable. It can arise higher than usual and can have a common origin with the above; sometimes double. It can be very thin or completely missing; in this case it is substituted either by the lateral tarsal artery or by the plantar arch by means of posterior perforating arteries.

The dorsal metatarsal arteries can, in greater or lesser number, proceed from the plantar arch by means of the posterior perforating arteries. Worthy of note is the antagonism which exists in the foot, as in the hand, between the development of the dorsal arterial system and that of the plantar system, as is also the compensation which is realized between one and the other.

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Anatomy of the Veins of the Lower Limbs

Vito D'Andrea, Sandro Colaiuda, Fabio Colaiuda, Laura Falvo

Vena Femoralis, Femoral Vein

V. femoralis extends upwards, from the end of the adductor canal (Hunter's canal), where it follows on from the popliteal vein right up to behind the inguinal ligament in the lacuna of the vessels where the external iliac vein takes over. It accompanies the femoral artery and the two vessels are covered in a single sheath that transmits a fine septum one to the other; above, the artery and the vein occupy the prismatic interstice which is situated in the Scarpa triangle. Where it begins, the vein is situated behind and lateral to the artery; moving upwards, it is situated firstly behind and then medial to the artery; the latter is the rapport that the two vessels have with one another in the upper part of the thigh. The femoral vein receives, as it courses upwards, the deep veins of the thigh; the long saphenous vein that rises from the foot and is the most important collector vessel of the superficial veins of the extreme abdominal bridge, of the veins of the external genitalia, and the superficial veins of the abdominal wall. The veins of the external genitalia and those of the abdominal wall can flow into the femoral vein directly or by means of the long saphenous vein.

In the femoral vein four or five pairs of valves are to be found. The femoral vein in a young person possesses a circular musculature which is normally rather developed; only after the thirtieth or fortieth year, with considerable variation among individuals, do longitudinal

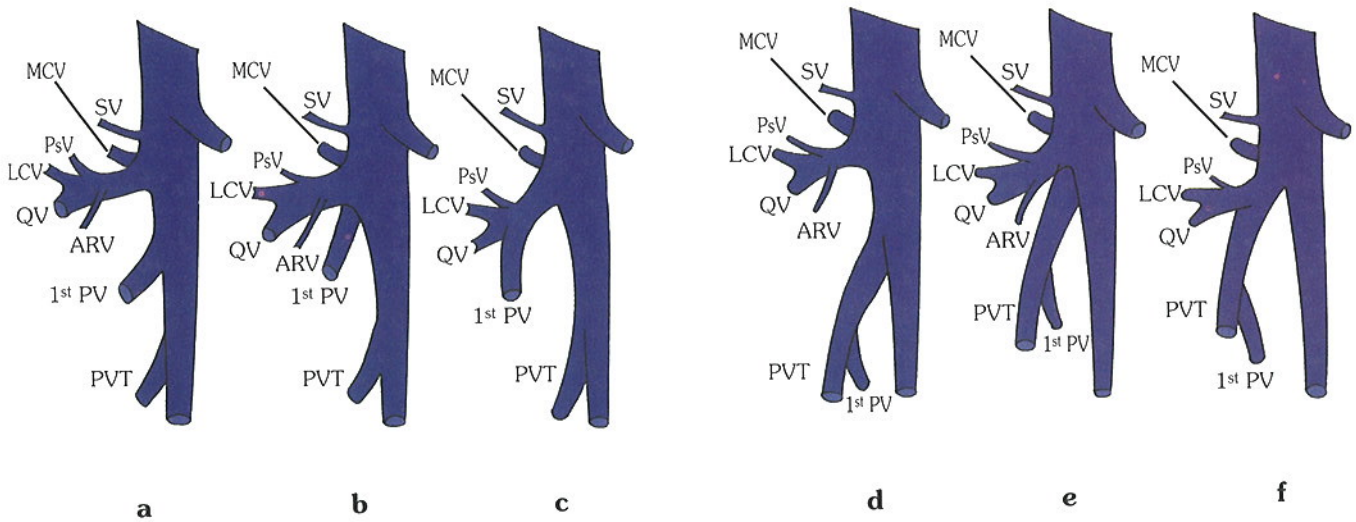

FIGURE 1

Femoral Vein: Anatomic Variations

a: The most Common Anatomic Feature
b: The First Perforant flows in the same Direction of the Lateral Circumflex Trunk and Quadricipital Trunk; the 2nd and 3rd Perforant Vein form another Trunk
c: The 1st Perforant Vein form a Common Trunk with Lateral Circumflex Vein and Quadricipital Vein
d: The Perforant Veins form a Common Trunk
e: Classical Anatomical Feature
f: The Circumflex Lateral Vein and Quadricipital Vein form a Common Trunk: "Deep Femoral Vein"

PVT = Perforant Venous Trunk
1st PV = 1st Perforant Vein
LCV = Lateral Circumflex Vein
QV = Quadricipital Vein
ARV = Anterior Rectus Vein
PsV = Psoas Vein
SV = Sartorius Vein
MCV = Medial Circumflex Vein

From Critical Lower Limb Ischemia Edited by R Bartolucci, L Battaglia, V D'Andrea, E De Antoni ©2002

contractual fasciae form in the adventitia, though remaining in minor amounts.

Besides the femoral vein, the femoral artery is accompanied by two or three small veins, *venae comitantes* – accessory veins, which originate from a network around the artery of the adductor canal; these move upwards, contained in the sheath of the vessels, and terminate in the principal trunk below the deep femoral vein. These receive collateral branches from the femoral vein and form a chain of anastomoses between these collaterals and the principal vein (Figure 1).

Observations. The femoral vein can be doubled for a short length, or, more rarely, for the whole of its length. The two veins move on each side of the artery or behind it. When the popliteal vein, keeping its normal form during its embryonic development, is found in wide junction with the ischial vein, the femoral vein is reduced in length and calibre. In anomalies genetically referable to the same group as the above, the popliteal vein can lengthen upwards further than normal and perforate the adductor magnus muscle at different levels, continuing then in the femoral vein or in the deep femoral vein or in both of these. There have been descriptions of a femoral vein which moves for a certain length in front of or outside the artery, and only higher up taking up its normal position.

Vena Poplitea, Popliteal Vein

V. poplitea is the distal segment of the principal vein of the extremity of the abdominal bridge, is situated behind the knee and extends from the tendon arch of the soleus muscle, under which it groups for the reunion of the anterior and posterior tibial veins, up to the adductor canal where it penetrates and changes name becoming the femoral vein.

Inverse connections in the flow of the popliteal cavity upwards, analogous to those of the similarly-named artery. It is held in the same sheath as the artery and adheres to it tightly; it is situated behind this, the crossing at X being medial below and slightly lateral higher up in relation to the artery; moving up the thigh the vein moved in a screw-like fashion becoming first posterior and then medial in relation to the similarly-named artery. The tibial nerve remains for the most part of its course behind and lateral to the vein; below, as the vein has been shifted laterally, the nerve ends up corresponding behind the artery.

The popliteal vein receives small collateral satellite veins of the muscle and articular branches of the popliteal artery; it receives, besides, the short saphenous vein, one of the principal collectors of the abdominal extremity, which rise from the instep. It anastomises, by means of an ascending branch, with the lower perforating veins.

The popliteal vein has the same structural characteristics as the femoral vein. It has two or three pairs of valves.

The popliteal artery is accompanied also by two small veins, accessory veins, one medial and the other lateral. They originate from the lower articulary veins and from the muscle veins, and anastomose with one another and flow into the popliteal vein.

Observations: in the case of a partial doubling it forms one or more eyelets; it can be doubled below or for the whole of its length. It can form at a level which is higher than normal; it can flow in front of the artery.

The Branches of the Femoral and Popliteal Veins

The femoral vein, by means of some collateral branches, and the popliteal vein, by means of its collateral branches and its originating branches, receive blood from the free part of the abdominal extremity. For the most part these vessels are satellites of the artery branches and derive principally from the muscles and from the skeleton, but some take their origin in an external system of veins, flowing below the skin and independent of the arteries. Some veins that arise in the external genitalia are directly or indirectly tributaries of the femoral vein. Finally there are emptied into the femoral vein, directly or indirectly, subcutaneous veins of the anterior lateral wall of the abdomen, some of which are satellites of the arteries, some with an independent course.

The above-mentioned veins are;

a) the deep veins;
b) the superficial veins of the free section of the abdominal extremity;
c) the veins of the external genitalia;
d) the subcutaneous veins of the abdominal wall.

The Deep Veins of the Free Section of the Abdominal Extremity

The deep veins of the free section of the abdominal extremity form a well-developed system, in relation with a full development of the muscle masses. They are satellites of the arteries, each accompanied by two veins. Directly or indirectly they are all tributaries of the popliteal vein and of the femoral vein.

They have many valves, which in these are more numerous than in the superficial veins and in the deep veins of the thorax extremity. Valves in the veins of the foot and leg are particularly numerous.

Transversal anastomoses between the satellite veins of a same artery are frequent.

The deep veins begin in the sole of the foot as *Vv. digitales plantares*, simple and fine, which converge among themselves to form the plantar metatarsal veins.

These unite at the deep plantar venous arch which continues in the *Vv. plantares laterales*, and these, uniting with the *Vv. plantares mediales*, which are finer, give rise to the *Vv. tibiales posteriores*. The venous plantar arch and the plantar veins accompany the similarly-named arteries.

The deep veins of the plantar surface of the foot receive branches of communication from the plantar venous network; some of these reach them on the margins of the foot, others, in good number, after perforating the plantar aponeurosis at the sides of the flexor digitorum brevis muscle. The same deep veins of the sole can then in their turn drain a part of the blood into the superficial veins of the back of the foot through perforating branches, anterior and posterior, which originate from the metatarsal plantar veins and by means of branches that move around the margins of the foot. The lateral plantar veins provide a anastomotic branch to the *V. saphena parva* and the medial plantar veins send a similar one to the *V. saphena magna*.

At the dorsum of the foot the deep veins are relatively thin. They originate in the intermetatarsal spaces as dorsal metatarsal veins and they collect in the *Vv. tibiales anteriores*. In the leg the posterior tibial veins, for the union of the plantar veins, receive the peroneal veins, compared to which they are generally much larger. Higher up, they unite at the anterior tibial veins and form together with these the origins of the popliteal vein.

These veins of the leg, doubled for each artery, of which they are satellites, possess numerous anastomoses; those which accompany each artery unite repeatedly with one another through transversal branches, the posterior tibials communicate through many branches with the peroneals and the former and the latter are in multiple conjunction with the anterior tibials.

The deep collateral branches of the popliteal vein accompany the articular and muscle arterial branches of the popliteal artery and are doubled for each of the corresponding arteries.

V. femoralis receives diverse deep collateral branches which come from the musculature and the skeleton of the thigh and are satellites of the arteries derived from the femoral artery.

V. profunda femoris is almost as voluminous as the trunk of the femoral vein; it accompanies the similarly-named artery and empties into the femoral vein in the Scarpa triangle. Its principal affluents are the *Vv. perforantes, Vv. circumflexae femoris mediales* and *Vv. circumflexae femoris laterales*.

Vv. perforantes, doubled in part, originate on the dorsal face of the adductor magnus muscle and are in broad communication with one another by means of longitudinal anastomoses. They unite higher up with the ischiatic and medial circumflex veins of the femur, and lower down with the popliteal vein, perforating with the similarly-named arteries the adductor muscles and re-emerge in the deep femoral vein.

Vv. circumflexae femoris mediales, satellites of the similarly-named artery anastomose behind, at the quadrate femoris muscle, with the ischiatic veins and firstly perforating, forwards with the obturatory vein.

Vv. circumflexae femoris laterales accompany the similarly-named artery and anastomose with the former and the ischiatic vein.

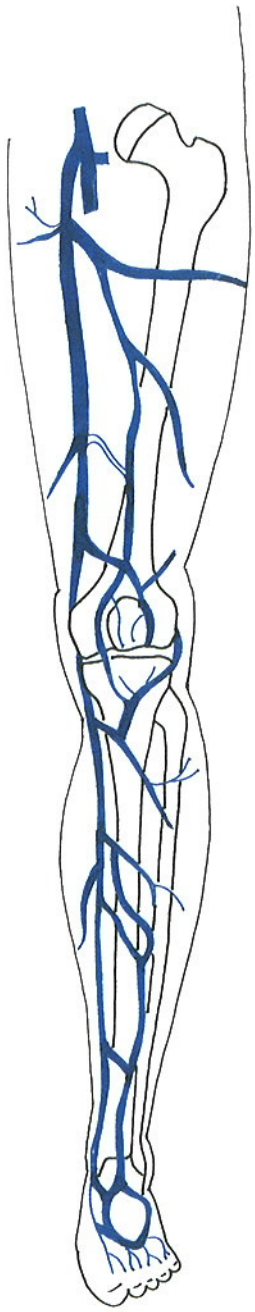

FIGURE 2
Superficial Veins of the Leg

Both the trunk of the deep femoral vein and its branches are provided with various valves.

The anastomoses that the deep femoral vein, inverted by means of its branches with the ischiatic and obturatory veins, tributaries of the hypogastric vein, form an important collateral route in the venous circulation of the abdominal extremity, which acquires a particular importance granted that it substitutes the femoral vein when this is obliterated or obstructed.

The superficial veins of the free section of the abdominal extremity
(Figure 2)

The superficial veins of the free section of the abdominal extremity form into a subcutaneous connection which is a mesh network which extends however the length of the principal axis of the artery, developed in varying ways in different regions. In this network there is a difference by virtue of their calibre between some collector vessels which flow into the principal emptying routes of the entire system represented by:

I. *V. saphena magna,* a tributary of the femoral vein,
II. *V. saphena parva,* a tributary of the popliteal vein.

The superficial veins are plentifully provided with valves, numerically fewer in the deep veins but more numerous in the superficial veins of the abdominal extremity. They have a thick wall and are rich in muscular tissue. The links between the superficial and deep veins are numerous; some anastomotic branches are avalvular, others have valves, some directed towards the surface, some directed towards the interior. In the foot, by means of anastomotic routes, the blood flow tends to move from the deep veins towards the surface or more exactly towards the superficial veins of the trunk of the foot. In the leg and the thigh, generally speaking, even if not in some absolute way, the opposite is true: from the superficial vein system the blood flow moves towards the deep vein system.

In the sole of the foot there is a venous arch, *arcus venosus plantaris cutaneus*, in the hollow that separates the phalanges from the adipose cushions which correspond to the heads of the metatarsal bones. This arch receives superficial veins arising from the plantar face of the toes, *Vv. digitales plantares*, which have their roots in a network developed in the digital pulp of the last phalanx and from behind receive small branches from the cutaneous plantar venous network. At each extremity the plantar arch ascends on the dorsum of the foot and is prolonged into the initial part of the marginal veins; other emptying routes of the plantar arch towards the veins at the dorsum of the foot and represented by intercapitular veins that flow across the interdigital spaces.

A closely woven venous network of fine vessels extends under the skin of the whole of the surface of the plantar surface of the foot, including the heel: *rete venosum plantare cutanea*.

Then at the periphery of the network small trunks repart which represent their emptying routes; in front these are tributaries of the cutaneous plantar venous arch; on the sides they move around the margins of the foot and emerge into the marginal veins of the trunk of the foot; from the heel they re-ascend terminating in the saphenous veins of the leg. The network communicates with the deep veins of the sole, both on the margins of the foot and through multiple small branches that perforate the plantar aponeurosis at the sides of the flexor digitorum brevis muscle.

The superficial veins of the sole are provided with numerous valves that direct the blood flow towards the back of the foot.

In the dorsum of the foot the superficial veins arise in the toes as specific dorsal digital veins, that flow along the margins and arise in a closely woven sub ungual plexus. The specific dorsal digital veins arise from the contiguous toes, after receiving the intercapillary veins, and join with these to form the common digital veins, which empty into *arcus venosus dorsalis pedis*.

The cutaneous dorsal venous arch is an irregular chain of anastomoses, that form in their group an arch with an anterior convexity, which rests on the distal part of the metatarsus. It receives in front the common digital veins and, at each of its extremities, the termination of the cutaneous plantar arch. Behind, it communicates with an irregular network of superficial veins, *rete venosum dorsale pedis*, which extends on the back of the foot and is extended into the leg.

The medial marginal vein and the lateral marginal vein, rather voluminous, flow on each margin of the foot in continuation of the cutaneous dorsal venous arch and in connection with the dorsal cutaneous network. These vessels, besides representing the principal emptying routes of the system of the dorsal veins, collect along their flow some emptying routes of the cutaneous plantar venous network. The medial marginal vein continues into the long saphenous vein, and the lateral marginal vein into the short saphenous vein.

To the system of the superficial veins of the back of the foot vessels arrive by means of which they can empty into them the deep veins of the sole; they are represented by numerous perforating branches of the intermetatarsal spaces and by others that move around the margins of the foot.

I. *V. saphena magna* (Figure 3) - The long saphenous vein or the internal saphenous vein is a superficial vein which extends from the instep along the medial face of the leg into the anterior medial of the thigh,

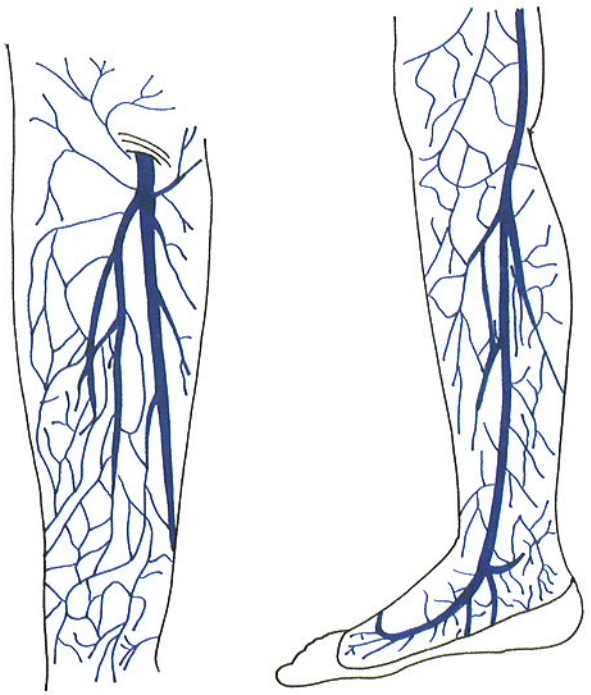

FIGURE 3
Long Saphenous Vein

until a short distance from the inguinal ligament. (Figure 4).

It originates in front of the medial malleolus as the prolongation of the medial marginal vein at the back of the foot and flows upwards. It flows first of all on the medial face of the tibia, then near the medial margin of this; it follows a slight curve with anterior concavity behind the medial condyle of the tibia and of the femur; when it reaches the thigh it moves up obliquely along the medial face and anterior to this, following the length of the sartorius muscle. When it arrives at the level of the oval fosse, it bends back and moving around the sickleform margin penetrates, through a wide opening of the cribroseous fascia, into the oval fosse and empties into the femoral vein, at a distance of 3.5 cm from the inguinal ligament.

For the whole of its length it is sub-cutaneous applied on the fascia of the leg and on the fascia lata. It is accompanied by a large group of superficial lymphatic vessels and, from the malleolus of the knee, it is bordered by the saphenous nerve.

The long saphenous vein has an average diameter of 3.5 mm and is somewhat dilated at its termination; its wall is substantial, with varying thicknesses, and rich in muscular tissue. Authors describe quite conspicuous structural transformations in it related to age; in the youngest the musculature is only in the middle and via circular direction; at the end of the first decade longitudinal fasciae appear in the adventitia, which progressively develop until they become a rather robust layer. Longitudinal musculature form also even in the media and the intima, revealing, however, in middle age, and even more in advanced age, a noticeable regression in circular musculature revealed in considerable rearrangement in the structure of this vessel, evidently deriving from hemodynamic conditions, in which morphogenetic stimuli mount up during life. Very evident characteristics of a "propulsor" type for the long saphenous vein result from this. There is also a consensual increase in the elastic materials in the areas of the venous wall related to differentiation of the contracture tissue and its progressive increase. The valves oscillate in number between 10 and 20, they vary in position and development, some atrophying progressively with age, becoming gradually insufficient and even in part disappearing completely. One osseal valve and another, which precedes the passage of the vein through the cribrous fascia, are frequently preserved.

The long saphenous vein receives at its source branches which arise from the cutaneous dorsal network

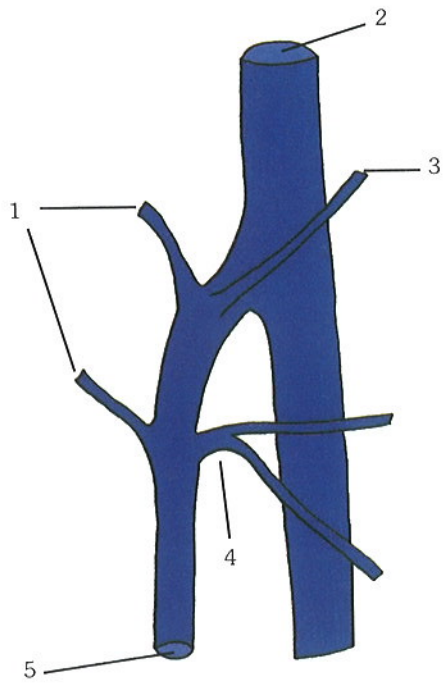

FIGURE 4
Saphenofemoral Junction

1. *External Pudendal Vein*
2. *Common Femoral Vein*
3. *Superficial Circumflex Vein*
4. *Anterior Accessory Vein*
5. *Long Saphenous Vein*

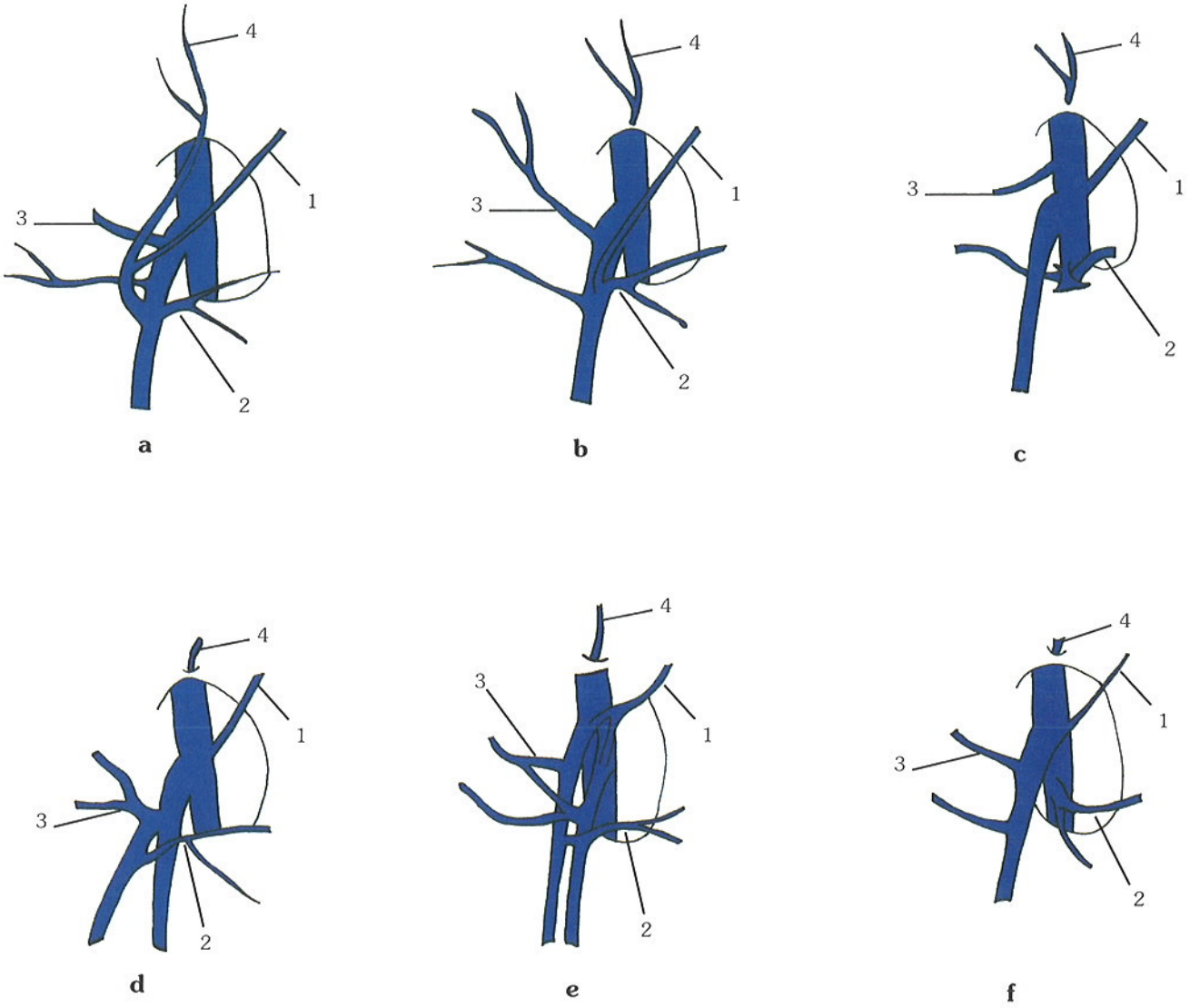

FIGURE 5

Anatomic Variations of the Saphenofemoral Junction

a. *A Common Trunk of the Anterior Accessory Vein, Superficial Circumflex Iliac Vein and Superficial Epigastric Vein*
b. *A Common Trunk of the Anterior Accessory Vein and Superficial Circumflex Iliac Vein*
c. *Separate Opening of the Superficial Veins in the Common Femoral Vein*
d. *A Common Trunk of the Accessory Vein and External Pudendal Veins*
e. *Confluence of two Internal Saphenous Veins at the Oval Fosse*
f. *An Opening of the Anterior Saphenous Vein at the Oval Fosse*

1 = Superficial Circumflex Iliac Vein
2 = Anterior Saphenous Vein
3 = External Pudendal Vein
4 = Superficial Epigastric Vein

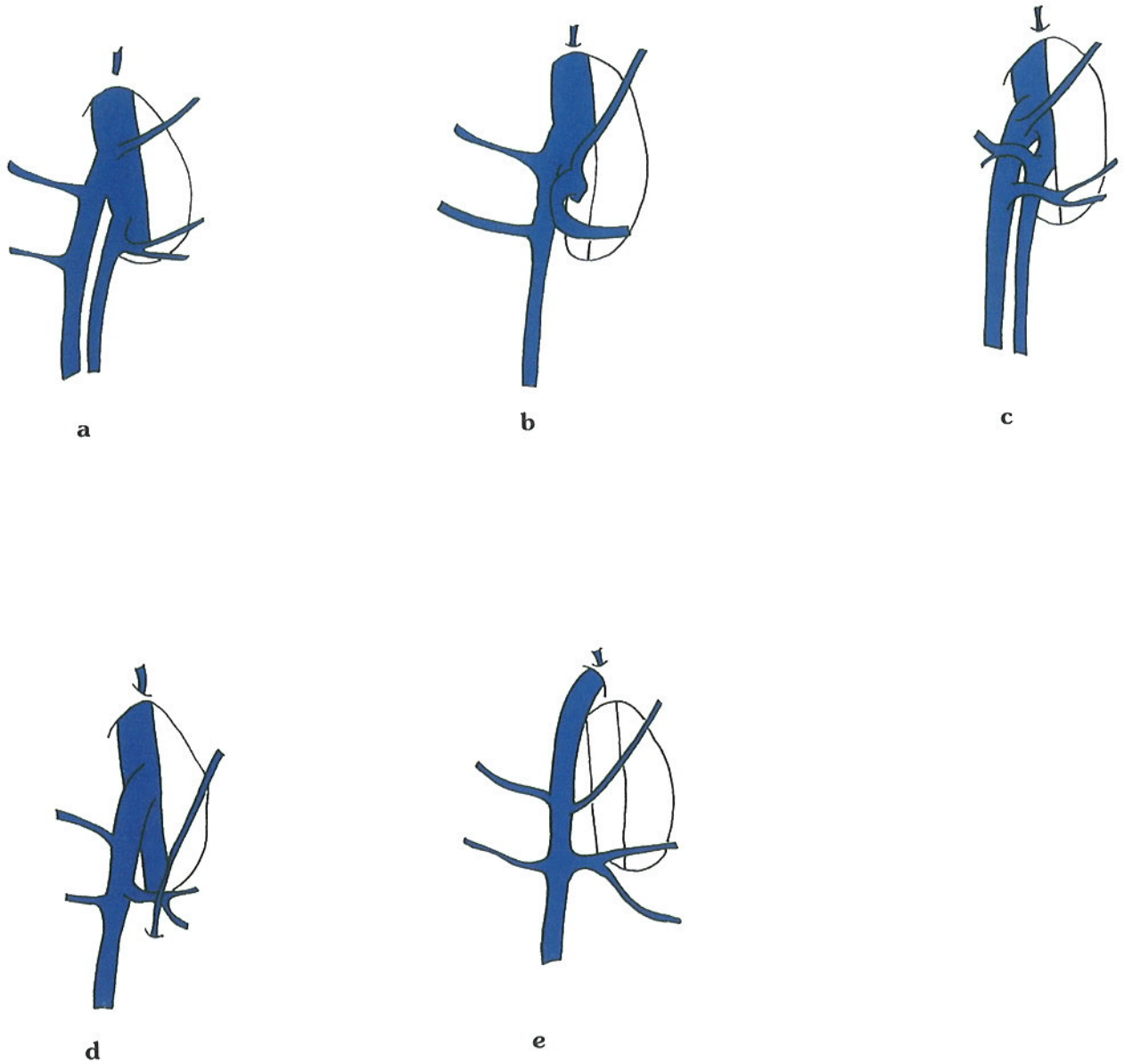

FIGURE 6

Anatomic Variations of the Saphenofemoral Junction

a. A Common Opening of the Anterior Vein and Posterior Accessory Saphenous Vein at the Oval Fosse
b. A Common Trunk of the Anterior Accessory Vein and External Circumflex Iliac Vein
c. A Common Trunk of Posterior Accessory Vein and External Pudendal Vein
d. An Opening of the Circumflex Iliac Vein into the Common Femoral Vein below the Oval Fosse
e. An Opening of the Internal Saphenous Vein into the Common Femoral Vein above the Oval Fosse

of the foot, which ascend from the medial section of the cutaneous plantar network and especially from the cutaneous network of the heel and one is the deep branch which emanates from the medial plantar veins. It drains most of the superficial veins of the leg and, more importantly, those which flow in the antero-medial part of this, and as well the nutritional veins of the tibia. It receives all of the veins of the thigh. Often those which come from the posterior and medial face of the thigh are collected in a vessel of considerable calibre, the accessory saphenous vein, which ascends medially and reaches the long saphenous vein at variable heights. Finally the superficial iliac circumflex veins and the superficial epigastric veins and the external pudendal veins, which sometimes are direct tributaries of the femoral vein, can empty into the long saphenous vein, close to its termination (Figure 5,6).

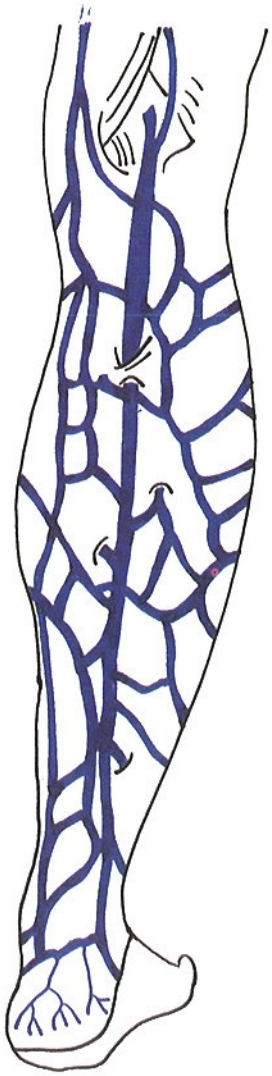

FIGURE 7
Short Saphenous Vein

The long saphenous vein is repeatedly anastomosed with the short saphenous vein both by means of the sub cutaneous network and through direct branches among which one, almost constant, is situated in the posterior part of the thigh. It communicates besides by means of perforating vessels with the deep veins system, the anterior and posterior tibial veins and with the femoral vein. These perforating vessels reach the principal deep trunks and their branches and are without valves or valvules; in some the valves are arranged in such a way as to enable the passage of the blood from the depth to the surface, in others they enable a flow in the opposite direction.
Observations. - The long saphenous vein of the leg can be missing and can be substituted by a plexus. It can double out giving origin to a ring-like formation, frequently around the medial condyle of the femur; it can also be doubled along the whole of its length. It can cross the fascia lata at varying levels; it can receive besides the accessory saphenous vein, an anterior saphenous vein which ascends from the region of the knee on the anterior face of the thigh.

II. *V. saphena parva.* The short saphenous vein or the external saphenous vein is a superficial vein which extends from the instep along the posterior fascia of the leg as far as the popliteal area (Figure 7). It originates behind the lateral malleolus as the prolongation of the lateral marginal vein of the dorsum of the foot. It flows initially along the lateral margin and then on the posterior face of the calcaneal or Achillean tendon; it ascends vertically opposite the sulcus and is situated between the two heads of the gastrocnemius muscle up to the inferior part of the popliteal region; it perforates at varying heights the fascia of the leg, enters into the popliteal hollow and terminates by opening out into the popliteal vein (Figure 8).
The short saphenous vein is subcutaneous along the first part of its flow and becomes subsequently subfascial. It is accompanied by a group of superficial lymphatic vessels and has as a satellite the medial cutaneous nerve of the leg, which is placed to the side, especially in the lower stretch; in the upper subfascial stretch it is linked to a branch of the posterior cutaneous nerve of the femur.
The vein has an average diameter of about 4 mm, with a rather thick wall and is rich in muscular interweaving, whose characteristics and structural modifications with relation to age are rather similar to those of the long saphenous vein, with elements of lower importance. It belongs to the group of "propulsor" veins and is provided with about 12 valves.
The short saphenous vein receives at its source superficial branches from the lateral part of the cutaneous plantar network and of the cutaneous network

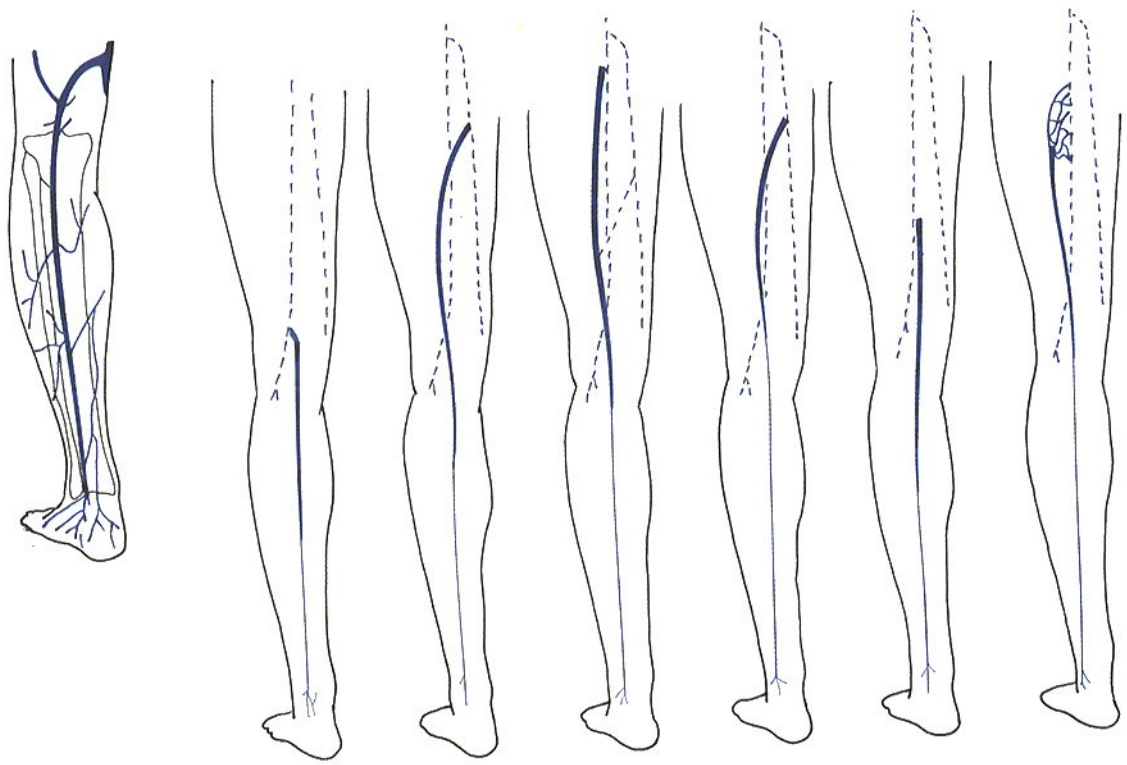

FIGURE 8

Origin, Course and Confluence of the Short Saphenous Vein and its Anatomic Variations

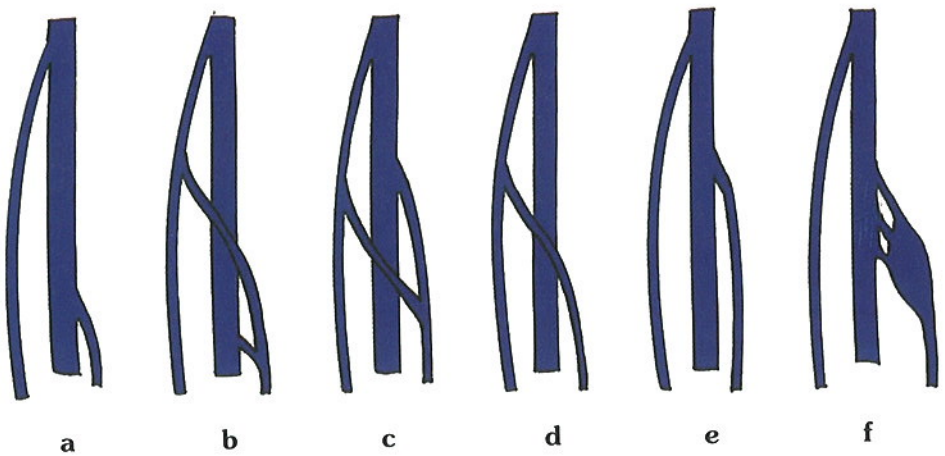

FIGURE 9

Variations in Anastomoses of the Short Saphenous Vein

a. *An Opening of the Short Saphenous Vein into the Popliteal Vein*
b. *An Opening of the Short Saphenous Vein into the Popliteal and Long Saphenous Vein*
c. *An Opening of the Short Saphenous Vein into the Femoral and Long Saphenous Vein*
d. *An Opening of the Short Saphenous Vein into the Long Saphenous Vein only*
e. *An Opening of the Short Saphenous Vein into the Femoral Vein only*
f. *A Delta Shaped Opening into Femoral Vein*

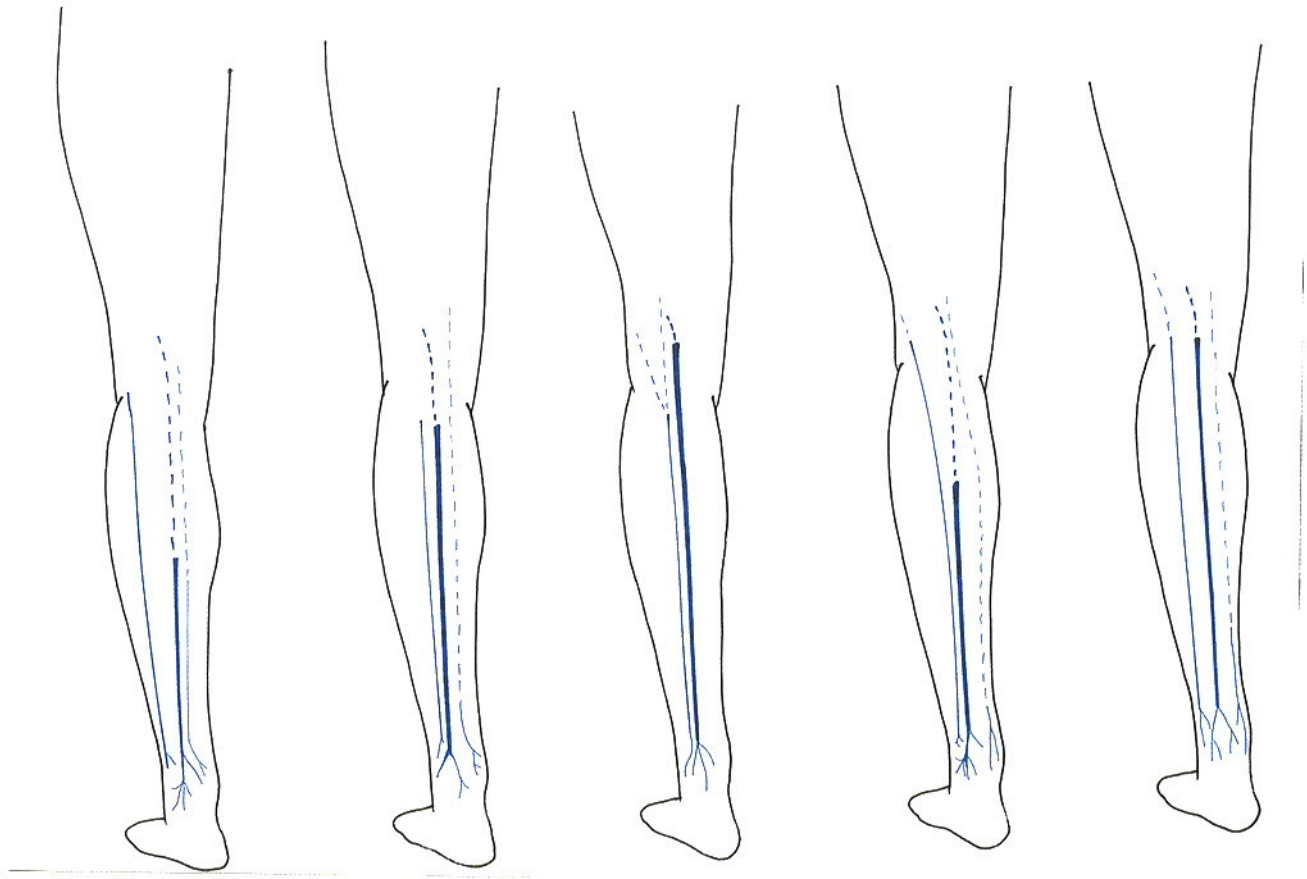

FIGURE 10
Variations in Course and Site of Perforation of Fascia by Short Saphenous Vein

of the calcaneal region, and a deep branch that comes from the lateral plantar veins. In the leg it collects cutaneous branches from the posterior face of this and from the popliteal region. In the popliteal cavity it receives the popliteofemoral vein, a branch flowing downwards which comes from the posterior face of the thigh.

The short saphenous vein communicates with the long saphenous vein by means of a subcutaneous network and of direct branches. One important connection and almost constant between the two vessels is represented by the superior anastomotic branch which detaches itself from the short saphenous vein a little before its outlet, moves up the thigh along its semimembraneous muscle, flows near the long saphenous vein firstly under the fascia and then in the subcutaneous collective, and terminates in the long saphenous vein at varying height. Perforating branches which detach themselves at varying heights unite the short saphenous vein with the deep veins of the leg. An anastomotic branch detaches itself from the short saphenous vein near its termination and reaches the initial part of the femoral vein.

Observations. - The superior anastomotic branch of the short saphenous vein can grow out to such a point that it could be said that this empties into the long saphenous vein. The short saphenous vein can open out in the higher part of the popliteal vein, and also into the femoral vein (Figure 9). The popliteofemoral vein can even reach to inside the pelvis, uniting with the ischiatic vein; this arrangement has one recall the one existing in the first embryonic period, when the ischiatic vein, a direct continuation of the short saphenous vein, is the principal vein of the inferior extremity, while normally in its femoral section it atrophies. The high termination of the short saphenous vein and its connection with the deep femoral vein are an imperfect preservation of this above arrangement (Figure 10).

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Standard Surgical Approaches to the Arteries of the Lower Limbs

Roberto Bartolucci, Luciano Battaglia, Enrico Leo, Vito D'Andrea

The femoral artery extends from the middle of the inguinal ligament (Poupart's ligament) as far as the third adductor ring, the so-called "Hunter's region", beyond which it continues with the name of popliteal artery. Its direction on the anterior face of the thigh is represented with a line which joins the middle point of the inguinal arch to the posterior margin of the medial femoral condyle.

Along this line three classical surgical approaches are described (Table I).

TABLE I
Surgical approaches to the femoral artery

1	Scarpa's triangle
2	Middle third of the thigh
3	Hunter's canal

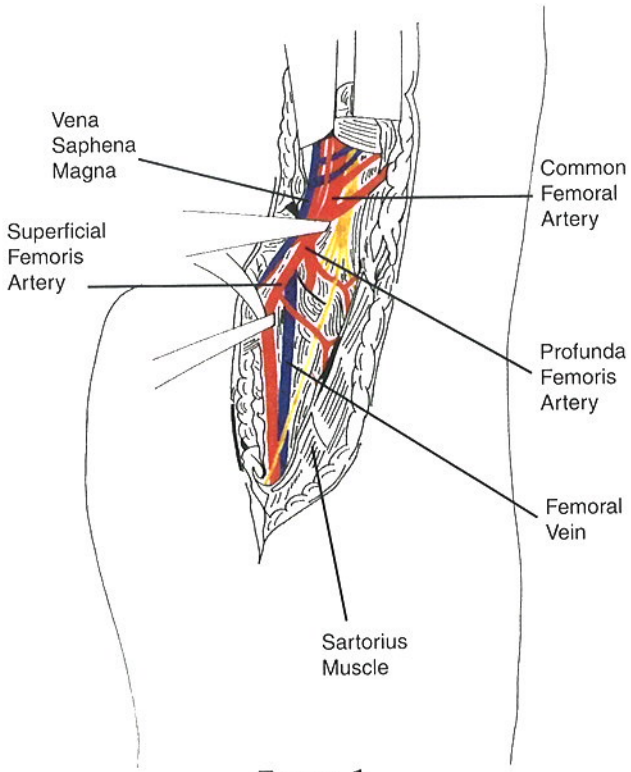

FIGURE 1
Surgical Exposure of the Proximal Segment of the Profunda Femoris Artery

Surgical approach to the common femoral artery, to the femoral carrefour and to the proximal portion of the profunda femoris artery
(Figure 1)

The femoral artery, the femoral carrefour and the proximal portion of the profunda femoris artery are located in the region which in anatomy is known as the "Scarpa's triangle", delimited above by the inguinal ligament, laterally by the sartorius muscle and medially by the adductor medialis muscle.

In the patient in a supine position the skin is incised along the femoral arterial course.

An 8-10 centimeters incision is recommended, with superior limit 1 cm above the inguinal ligament towards the abdominal wall. The incision can be curved towards the external face, with the aim of preventing lymphonodes; the common femoral artery must be prepared and isolated.

The dissection can thus be carried out downwards to dominate the superficial femoral artery. The origin of the profunda femoris artery is exposed, whose isolation in its distal portion is complicated by the presence of circumflex and quadricipital veins, which cross it and which, whenever there is a need for complete exposition, must be isolated and sectioned.

This surgical approach provides the opportunity for extending the access (Table II).

TABLE II
Possibility of extending the surgical approach

1.	above: with the Farabeuf incision, whenever there is the need for exposition of the external iliac artery only;
2.	above: with a pararectal incision, whenever it is necessary to expose the common iliac axis ;
3.	below: towards the popliteal artery, carrying out the dissection along the arterial line of projection.

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Surgical approaches to the superficial femoral artery

Surgical approach to the superficial femoral artery at the medial third of the thigh (Figure 2)

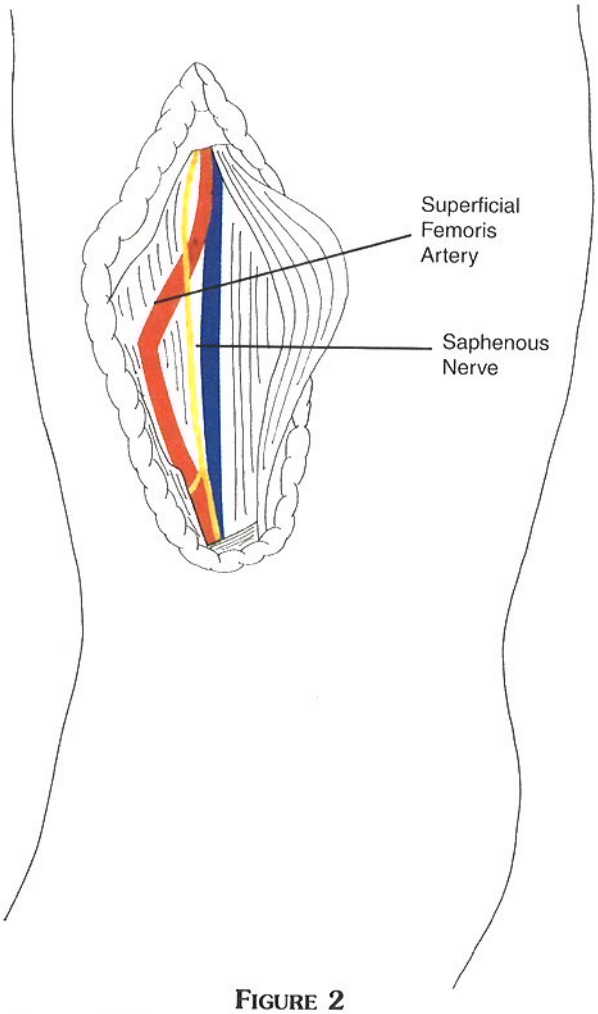

FIGURE 2
Surgical Exposure of the Superficial Femoral Artery at the midtigh

With the thigh extended, and slightly abducted and turned outwards, a dissection of the cellular tissue and the superficial fascia is performed. The superficial fascia is incised on the sartorius, and once isolated, this muscle is divaricated towards the exterior; at the opening of the posterior sheet of its fascia, appears the vascular bundle contained between the adductor muscles and the quadricipitis femoris muscle, with the femoral vein outside and the greater saphenous vein inside. During the dissection are encountered the internal saphenous nerve, the nerve of the vastus medialis and the saphenous nerve within.

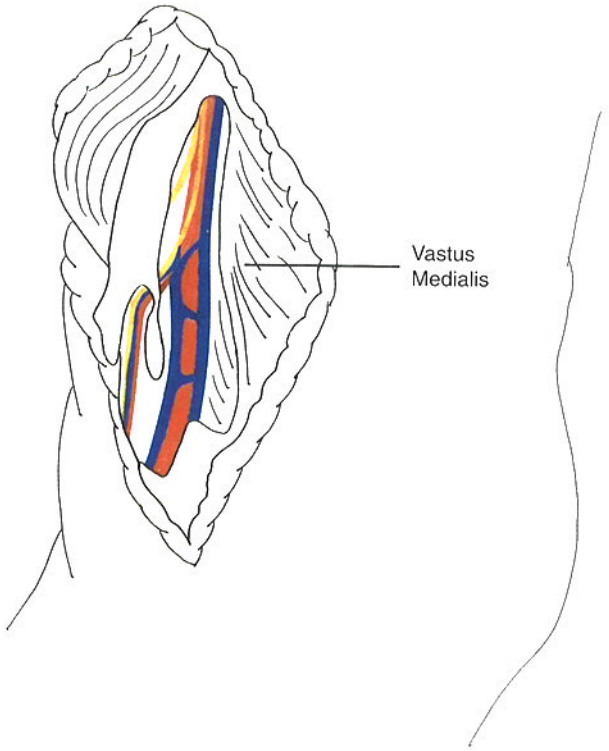

FIGURE 3
Surgical Exposure of the Superficial Femoral Artery at the Hunter's Canal

Surgical approach to the superficial femoral artery at the "Hunter's canal" (Figure 3)

The adductor canal or the "Hunter's canal" is the third and last segment of the sheath of the femoral vessels formed frontally by the portion of the femoral fascia which covers the deep face of the sartorius, medially by the medial intermuscular septum, and laterally by the sheath of the vastus medialis muscle.

The patient is placed in supine position with the thigh flexed and abducted and the incision is made along the inferior part of course of the artery.

After the skin, the subcutaneous tissue, and the fascia, have been sectioned, the sartorius muscle, which must be retracted medially, is liberated.

The anatomic landmark is provided by the tendons of the adductor magnus muscle which may be made evident by flexion with the abduction of the thigh.

Once the sartorius muscle has been retracted medially, the femoral sheath, reinforced by the archiform and transversal fibres, must be incised as close and parallel as possible to the tendon of the adductor magnus muscle and the distal portion of the superficial femoral artery can be isolated. Proceeding in the surgical approach downwards, the high portion of the popliteal artery can be reached.

Surgical approach to the popliteal artery

The popliteal artery, begins at the level of the adductor tertius and ends at the level of the soleus muscle ring, after which it divides into its terminal branches, the tibioperoneal trunk and the anterior tibial artery; this passes through the popliteal compartment for the whole of its length. Its line of course follows the axis of the popliteal groove as far as the soleus muscle ring.

Three surgical segments of the popliteal artery can be described (Table III).

TABLE III
Surgical segments of the popliteal artery

1)	proximal segment: from the ring of the adductor tertius to the gastrocnemius muscle groove.
2)	middle segment: in the gastrocnemius muscle groove behind the articulatory line
3)	distal segment: from the extremity of the gastrocnemius groove to the soleus muscle arch.

However, from a surgical point of view, we may consider essentially two portions, the high popliteal artery and the low popliteal artery segment.

Internal surgical approach

This surgical approach offers the advantage of enabling the supine position and enables, when necessary, an extensive exploration of the artery trunk.

The patient is placed on the operating table in supine position with the knee flexed and the inferior limb abducted and turned outwards.

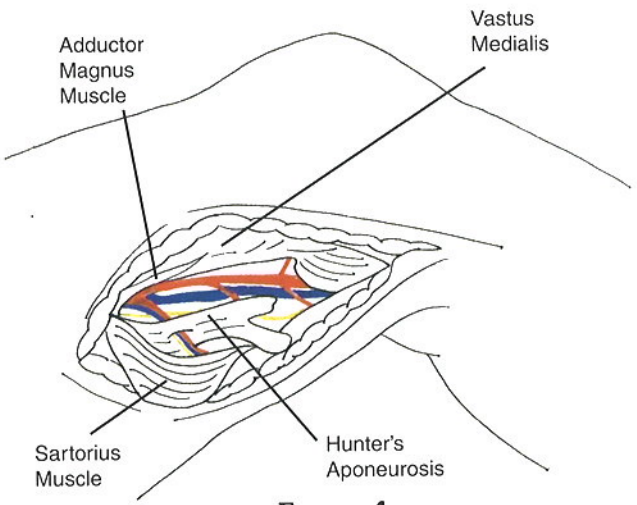

FIGURE 4
Surgical Exposure of the High Popliteal Artery Segment

Access to the high popliteal artery segment (Figure 4)

The incision begins below the apex of the rotula and moves up to the level of the Hunter's region, four fingers higher than the superior margin of the medial condyle of the femur.

When the fascia of the sartorius has been incised, the interior margin of the same muscle must be isolated and this is then retracted internally.

After the posterior sheet of the fascia of the sartorius muscle has been incised, the tendons of the "pes anserinus" must be retracted posteriorly.

The vascular pedicle will be thus evidenced and exposed in the adipose tissue.

Access to the low popliteal artery segment (Figure 5)

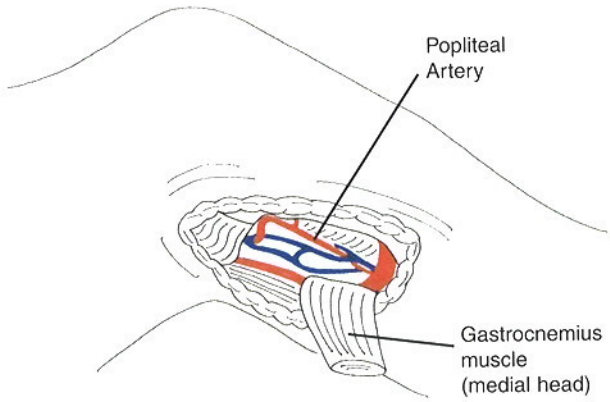

FIGURE 5
Surgical Exposure of the Low Popliteal Artery Segment

The incision is made beginning five fingers below the apex of the rotula and terminates above at the posterior edge of the medial femoral condyle. The incision must be carried out parallel to the internal margin of the tibia, about 1 centimeter posteriorly.

The aponeurosis is incised posterior to the internal margin of the tibia and then is continued upwards following the posterior margin of the sartorius muscle and of the semitendinous.

The tendons of these two muscles must be reclined forwards. Finally, reclining the tendon of the medial gastrocnemius muscle upwards, the vascular-nerve pedicle is evidenced in depth. This access can be widened below disinserting the soleus muscle from the tibia or sectioning the soleus arch and incising the same muscle vertically.

Extended access to the popliteal artery (Figure 6)

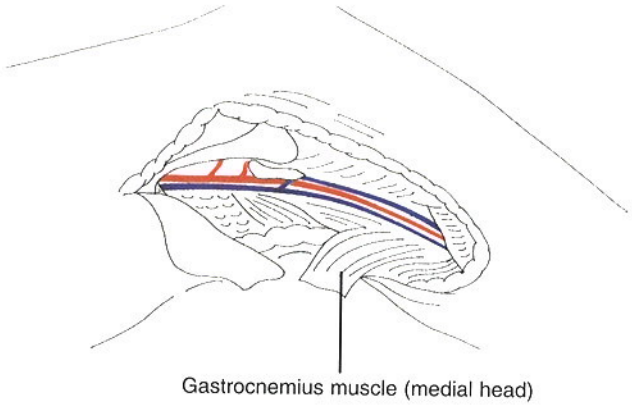

FIGURE 6
Internal Extended Surgical Approach to the Popliteal Artery

The extended access results from the combination of the popliteal surgical approaches previously described.

The two segments of the artery (high and low) are isolated, and the middle portion of the popliteal artery remains hidden by the tendons of the "pes anserinus" and by the medial gastrocnemius muscle.

The four muscles may also be sectioned with the aim of enabling subsequent reconstruction.

Posterior surgical approach to the popliteal artery

This represents a direct and anatomical access that does not require sectioning of the muscles: however this is limited by three major factors (Table IV).

TABLE IV
Limits of the posterior approach to the popliteal artery

1	prone position of the patient
2	limitated possibility of upward extending (distal)
3	no possibility of downward extending (proximal)

To prevent these inconveniences, as an alternative approach, the patient may be placed on the operating table laterally on his healthy side. This position, however, does not permit the control of the femoral artery at the Hunter's canal nor the controlateral iliofemoral axis.

Access to the high popliteal artery segment

The incision, median and vertical, above the flexor fold of the knee, enables the high part of the popliteal artery to be exposed. When the skin, the subcutaneous tissue, and the superficial fascia have been incised, the lesser saphenous vein is revealed, whose crosse represents an anatomic landmark.

The vascular-nerve pedicle is found on the median line, beyond the layer of adipose tissue which covers the deep aponeurosis; the artery represents the deepest element.

Access to the low popliteal artery segment (Figure 7)

The incision is made on the median line vertically,

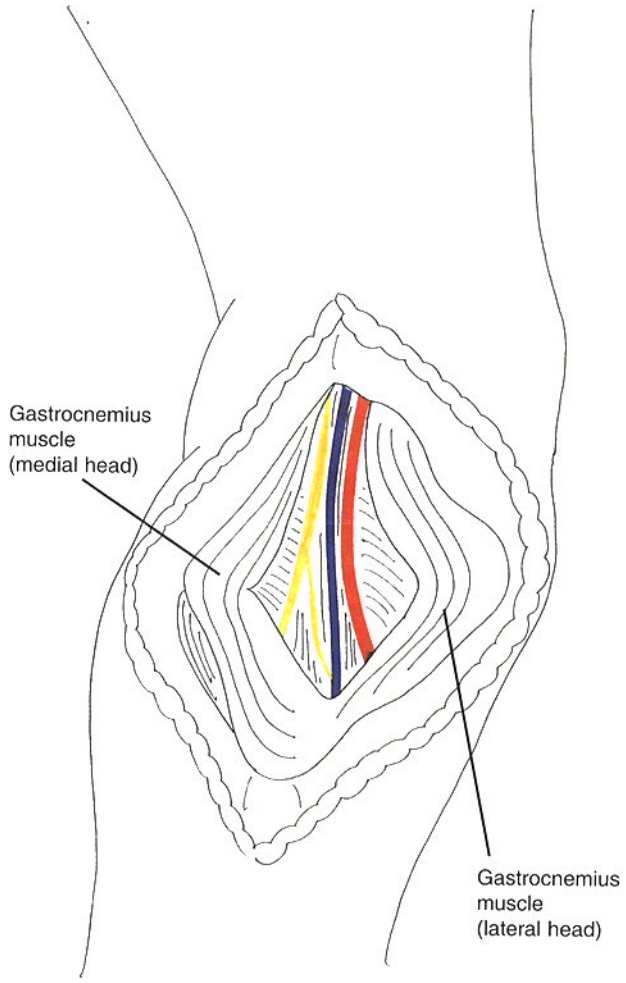

FIGURE 7
Posterior Surgical Approach to the Popliteal Artery (Low Portion)

below the flexor fold of the knee; when the superficial aponeurosis is incised and taken to the interior of the lesser saphenous vein, the medial and lateral gastrocnemius muscles are divaricated. In the middle of these muscles the adipose tissue appears in which the internal popliteal sciatic nerve, the popliteal vein and artery are revealed. The dissection can be extended, whenever

necessary, downwards sectioning the fibres of the soleus muscle.

Extended access to the popliteal artery

This access results from the fusion of the two approaches previously described. To avoid retraction of the scar, a "S- shaped" incision can be performed, as an alternative.

Arnaulf-Benichoux surgical access to the popliteal artery

This access represents an alternative approach to the simultaneous access of the popliteal and to the arterial axis higher up associating above the internal route and below the posterior route.

Surgical approaches to the tibioperoneal trunk

The tibioperoneal trunk, a medial branch of division of the popliteal artery, originates about 2 cm below the arch of the soleus muscle and extends for the length of two fingers subdividing into a medial branch, popliteal artery and peroneal artery.

Its course, on the posterior face of the leg, continues for about 4 cm the vertical of the popliteal artery.
Classically, three surgical approaches are described (Table V).

TABLE V
Surgical approaches to the tibioperoneal trunk

1	median posterior access
2	internal access
3	external trans-peroneal access

Median posterior access

Actually this access has already been described for the low popliteal artery segment. In fact, the same approach, through a further dissection of the fibres of the soleus muscle, permits an adequate exposition of the tibioperoneal trunk and the proximal portion of the anterior tibial artery.

Internal access

Even this access has already been described for the popliteal artery approach, by means of the disinsertion of the fibre of the soleus muscle of the tibia and retracting this backwards the tibioperoneal trunk can be isolated for the whole of its length.
External transperoneal access

This is the surgical approach of choice for the the tibioperoneal trunk and above all for the proximal segment of the anterior tibial artery.

The incision begins above the head of the fibula and continues in the direction of the external malleolus. (Figure 8)

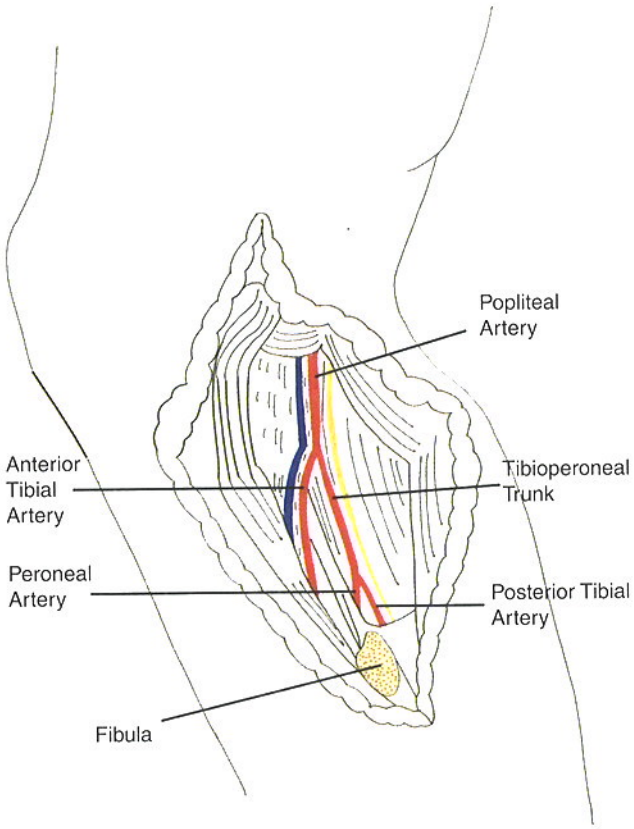

FIGURE 8
External Transperoneal Access

After the skin and the subcutaneous tissue are incised the superficial fascia is incised from above along the margin of the tendon of the long biceps muscle downwards separating the lateral gastrocnemius muscle from the intermuscular septum. During this surgical maneuver the external popliteal sciatic nerve is found, which must be identified.

The lateral gastrochemius muscle, previously isolated, must be divaricated externally for the purpose of facilitating the sectioning of its tendon fibres.

With this manoeuvre the insertion of the soleus muscle on the external margin of the peroneal bone can be controlled and thus we may proceed to its disinsertion.

At this point, the fibula must be sectioned in the lowest part of the incision.

The bone segment must be liberated from the muscular insertions, and the interosseal membrane and the tibioperoneal joint must be opened.

The vascular pedicle is encountered in the distal portion of the popliteal artery, in the distal direction.

This surgical approach offers a broad operative field, creating, however, considerable disadvantages (Table VI).

TABLE VI
Disadvantages of the transperoneal surgical approach

a.	risk of lesion of the fibres of the external popliteal sciatic nerve
b.	difficulty of extending the surgical approach
c.	immobilisation of the patient in the post-operative period

Surgical approach to the anterior tibial artery

The anterior tibial artery, a branch of anterior bifurcation of the popliteal artery, originates below the soleus muscle ring.

Its course, on the anterior-lateral face of the leg, is represented by a line that goes from the tubercle of the anterior tibial muscle (Gerdy's tubercle) to the middle point of the line which unites the two malleolus. Classically two segments are described (Table VII).

TABLE VII
Surgical segments of the anterior tibial artery

1	proximal segment (crosse)
2	distal segment (trunk)

The patient is placed on the operating table in supine position, with the knee flexed and the limb turned inwards.

Along the arterial course an incision of about 10 cm must be made until the superficial aponeurosis is reached.

The aponeurosis must be incised in the space between the anterior tibial muscle and the extensor digitorum comunis muscle; higher up the anterior tibial muscle extends to cover the common extensor digitorum comunis muscle. The anterior tibial muscle is found deep down towards the inferior limit of the incision.

This access can be widened downwards until two fingers above the tibiotarsal joint.

At this level, the lower third of the leg, after the superficial aponeurosis has been incised, the tendon of the anterior tibial muscle must be reached and finally the anterior tibial artery, which is found between the tendon of this muscle on the inside and the tendon of the extensor digitorum comunis muscle on the outside, is exposed.

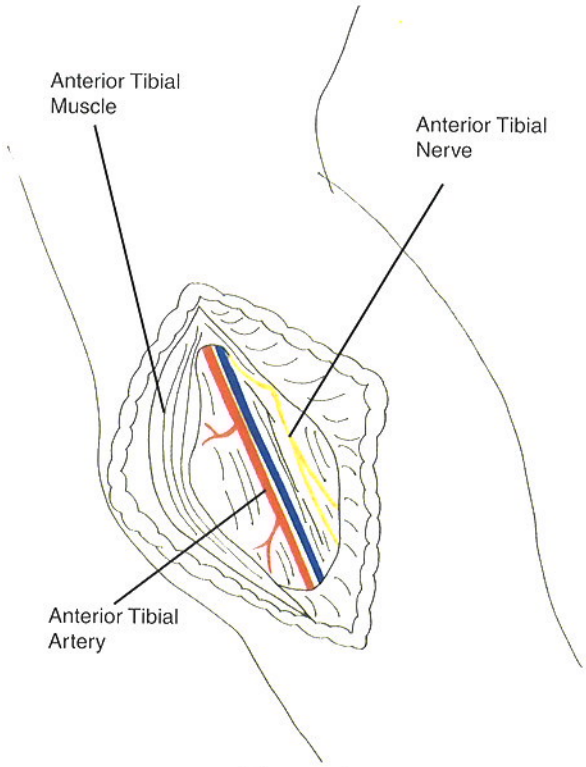

FIGURE 9
Surgical Exposure of the Anterior Tibial Artery

Surgical approach to the posterior tibial artery

The posterior tibial artery represents the branch of medial division of the tibioperoneal trunk, originating 4 centimeters below the arch of the soleus muscle and it moves towards the internal calcaneal groove.

Its course is represented by a line that unites the posterior edge of the medial femoral condyle at the middle point of the internal retromalleolar groove, between the tendo calcaneus (Achilles' tendo) and the malleolus.

Surgically, two segments are described (Table VIII).

TABLE VIII
Surgical segments of the posterior tibial artery

Proximal segment
Distal segment

The patient is in supine position, with the thigh abducted, the knee flexed and the foot turned outwards.

Surgical exposure of the proximal segment

The incision, about 10 centimeters, is made parallel to the posterior margin of the tibia, along the superior portion of the arterial line of projection.

When the deep fascia has been incised, must be retracted internally the medial gastrocnemius muscle; the exteriorisation of the posterior tibial artery can be performed both through the sectioning of the fibres of the soleus muscle or through the disinsertion of the soleus muscle of the tibia.

The trans-soleal access involves the perpendicular sectioning of the fibres of the soleus muscle through which one reaches the space that separates the triceps muscle from the deep muscles, a space in which is found the vascular pedicle covered by the deep aponeurosis, which must be incised (Figures 10).

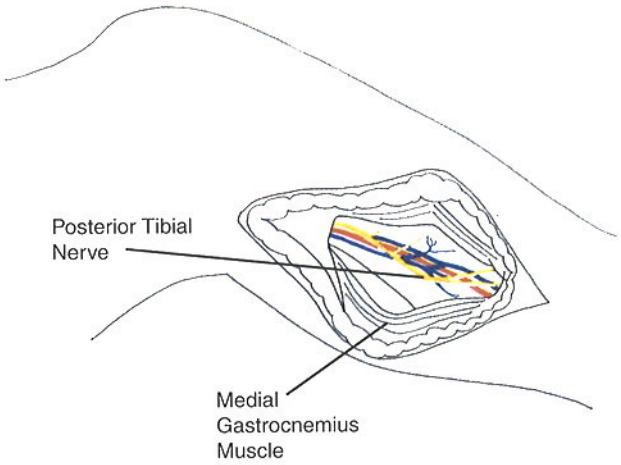

FIGURE 10

Trans-soleal access to the Posterior Tibial Artery

The retro-tibial approach involves the disinsertion of the fibres of the soleus muscle from the internal margin of the tibial bone (Table IX).

TABLE IX

Surgical approach to the posterior tibial – proximal portion

Trans-soleal approach
Retro-tibial approach

Surgical exposure of the distal segment

This is carried out by means of an incision of 6-8 centimeters in the retromalleolar groove, between the tendo calcaneus and the internal malleolus (Figure 11).

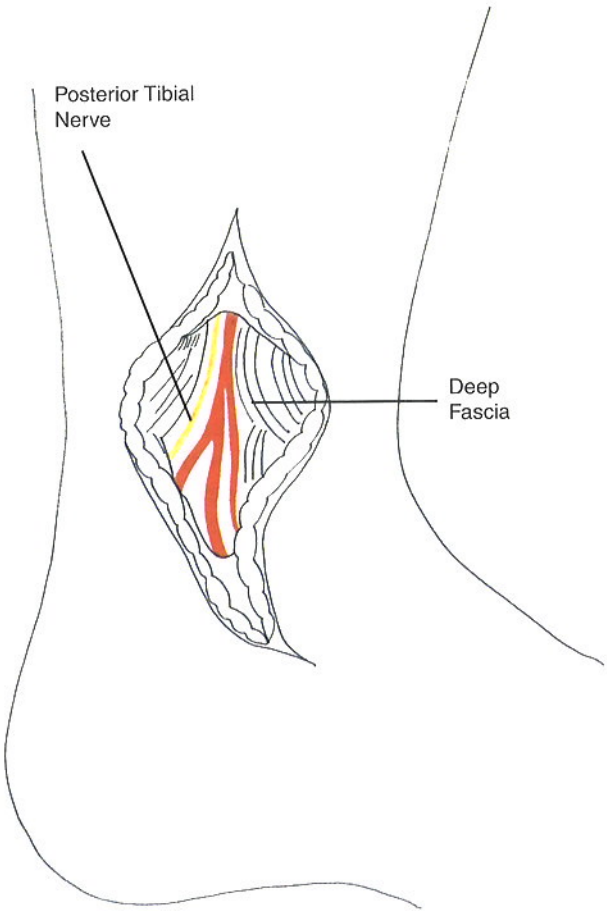

FIGURE 11

Surgical Exposure of the Distal Segment of the Posterior Tibial Artery

After the skin has been incised, the superficial and the deep aponeurosis are incised, which thus permits the surgical exposure of the posterior tibial artery surrounded by the satellite veins.

Surgical approach to the peroneal artery

The peroneal artery can be exposed following the internal surgical approach, which enables access to its first tract, or through the lateral trans-peroneal surgical approach, which enables exposition of its first portion. However, the classical approach is represented by the posterior-lateral access which involves the patient's being placed on the operating table lying sideways on the side which is not being operated on.

Alternatively, the extendeded median posterior surgical approach can be used (Table X).

TABLE X
Surgical approaches to the peroneal artery

Medial approach
Transperoneal lateral approach
Posterior-lateral approach
Posterior-median extended approach

Posterior-lateral access

The incision, about 10 centimeters, is carried out starting from the retroperoneal depression and 1 centimeter posterior to the posterior edge of the external malleolus.

The soleus muscle in incised two fingers inside the external margin of the fibula. Thus the muscular aponeurosis, which must be opened, is reached; now the vascular-nerve pedicle with the tibia nerve and the peroneal artery covered with satellites veins is exposed; these veins must be dissociated and divaricated in such a way that the underlying peroneal artery is exposed.

The extended posterior-median access (Figure 12)

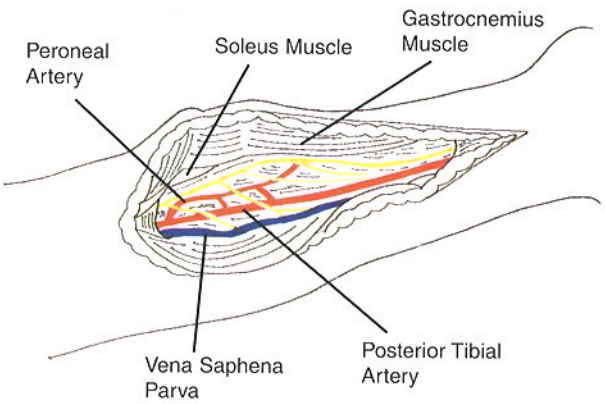

FIGURE 12
Extended Posterior Median Access to the Peroneal Artery

This surgical approach permits the surgical exposure of the two posterior arterial axes of the leg. This access requires the prone position of the patient.

The incision is vertical inside the median line, and it moves as far as two fingers below the median part of the tendo calcaneus.

The lesser saphenous vein, isolated on the surface, is divaricated externally and the gastrocnemius muscles are separated vertically, then the soleus muscle is incised in its median portion. Once the soleus muscle has been incised, the deep aponeurosis which covers the nerve appears, and inside this nerve may be find the veins and the peroneal artery, which is crossed by the posterior tibial nerve.

Surgical approach to the dorsalis pedis artery (Figure 13)

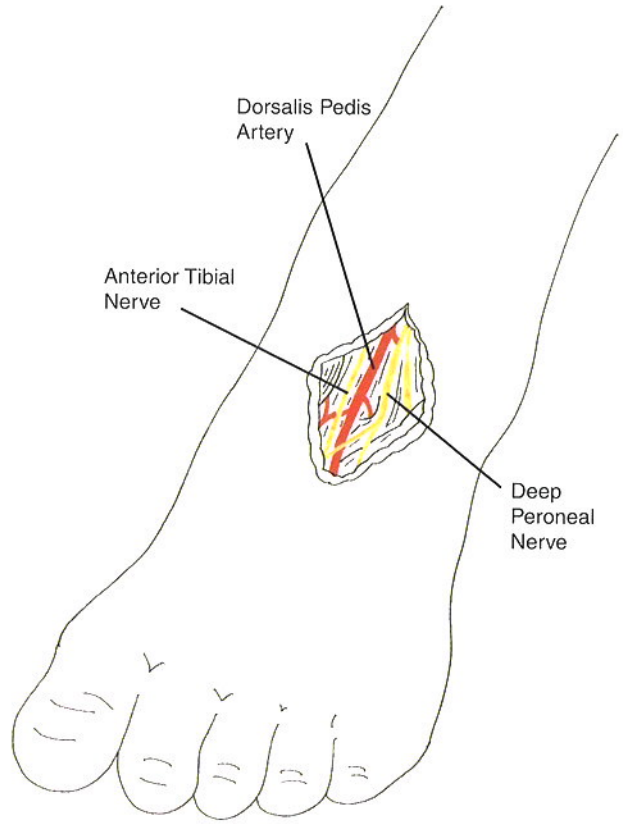

FIGURE 13
Surgical Approach to the Dorsalis Pedis Artery

The dorsalis pedis artery at the dorsum of the foot originates at the middle point of a line which connects the two malleolus and terminates in the first intermetatarsal space.

The patient is lying in a supine position with the foot extended first.

Along the line of arterial course an incision is made of about 6 cm which reaches below the I metatarsal space.

The incision is parallel and lateral to the tendon of the extensor hallucis longus muscle.

When the skin, the subcutaneous tissue and the superficial fascia have been cut the tendon of the above-mentioned muscle can be seen.

Lateral to the tendon of the extensor hallucis longus

muscle may be expose the fascia of the dorsalis pedis muscle or the extensor digitorum brevis muscle; when the fascia is opened, the tendon of the extensor hallucis brevis muscle is exposed.

The dorsalis pedis artery must be sought between this tendon and the tendon of extensor hallucis longus muscle.

During this isolation must be identify and deal carefully with the anterior tibial nerve which is found inside the dorsalis pedis artery.

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Nonstandard Surgical Approaches to the Arteries of the Lower Limbs

Roberto Bartolucci, Luciano Battaglia, Enrico Leo, Vito D'Andrea

Despite technical advances in the last decade, infrainguinal arterial reconstructions have a failure rate of roughly 20% to 30% at 5 years follow-up (1).

Secondary revascularizations are an important component in the overall approach to chronic lower-limb ischemia (2).

These secondary revascularization can be more challenging than primary procedures because of scarring, infection and lack of an adequate autologous vein (2,3).

Therefore, to avoid these surgical problems a variety of alternative approaches have been described (4,5) (Table I).

TABLE I
Nonstandard approaches to peripheral arteries

- √ Obturator foramen approach
- √ Femoral carrefour nonstandard approach
- √ Profunda femoris artery nonstandard approaches
- √ Combined anterior and posterior approach to the middle segment of the popliteal artery
- √ Popliteal artery lateral of the knee approaches
- √ Descending artery of the knee approach
- √ Crural arteries nonstandard approaches
- √ Inframalleolar arteries approaches

Obturator foramen approach

The obturator foramen is framed by the bony structures of the ischium and pubis. The obturator foramen is small and triangular – shaped in females than in males, in whom the shape is circular.

The obturator membrane and obturator internus and externus muscles fill the obturator foramen.

Althuogh the obturator membrane is described as a thin fibrous sheet, the fibers are densely interlocked, making the membrane difficult to penetrate.

At the superior portion of the foramen, the obturator nerve and artery penetrate the membrane.

The obturatory artery arises from the internal iliac artery or branch in 60 to 70 % of patients. In 27% of the patients it arises from the inferior epigastric artery and in the remaining 3 to 13 % from the external iliac artery (6). Muscular branches provides blood supply to the obturator externus, adductors, pectineus and gracilis muscles.

The obturator nerve have motor and sensitive fibers and supply hip and knee joint and the adductor longus, gracilis, adductor brevis, obturator externus and adductor magnus muscles.

In 29% of the cases, an accessory nerve is present and it don't pass through the foramen but crosses over the superior ramus (7).

The obturator foramen bypass is performed in two step procedure. The first consists in the exposure, through a retroperitoneal approach, of the iliac arterial arborisation, including the common iliac artery, the hypogastric artery and external iliac artery.

The perivescical space is developed between the obturator foramen and the bladder. The ureter must be identified during dissection. The obturator foramen is identified, along with the location of the obturator vessels and nerves.

The second step of the procedure begins with an incision in the midthigh, just below the adductor longus tendon, with the leg abducted and externally rotated.

The tunnel is then created below the adductor longus and magnus. Thus a tunnellizer is passed upward from below and direct toward the obturator foramen.

The tunnellizer is direct away from the obturator foramen, which lies at the anteromedial corner of the foramen, and the membrane is perforated. The bladder must be protected from perforation during this time (8).

Femoral carrefour nonstandard approach

Starting just below the anterior superior iliac spine, a curved incision is made that is concave anteriorly and medially.

After continuing the incision of the subcutaneous areolar tissues just below the skin and without underdetermining the cutaneous covering, the fascia lata is approached in the interstice between the tensor fascia lata and the sartorius muscle.

As the fascia is incised, the posterior branch of the lateral cutaneous femoral nerve may be divided, whereas the anterior branch usually remains in the upper margin of the incision. The thigh is then positioned in a slight external rotation and abduction, relaxing the sartorius muscle.

From Critical Lower Limb Ischemia Edited by R Bartolucci, L Battaglia, V D'Andrea, E De Antoni ©2002

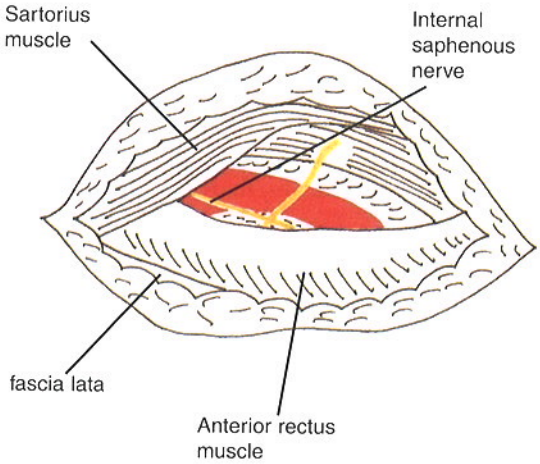


FIGURE 1
Lateral approach to femoral carrefour: retraction of the sartorius muscle. It is possible to see the internal saphenous nerve and the sensitive branches of the femoral nerve

The posterior aspect of the sartorius muscle is dissected free and the avascular plane is followed medially in front of the rectus femoris and vastus medialis muscles.

As the two upper muscular branches are encountered, they are ligated so that the muscle can be retracted anteriorly.

At this stage, as the posterior aspect of the psoas muscle is approached, the principal danger is the risk of damage to the anterior branches of the femoral nerve, particularly the anterior cutaneous, the medial cutaneous, and the saphenous nerves.

By means of this approach, the entire length of the common femoral artery is exposed through its lateral aspect, thus avoiding injury or disinsertion of the collateral branches of the femoral artery.

The first centimetres of the profunda femoris artery are exposed and the artery can then be clamped. Further dissection of the profunda femoris artery isn't possible through this approach.

The superficial femoral artery is exposed behind the sartorius muscle (9).

The branches arising from the medial aspect and femoral vein are not dissected.

Proximal anastomosis of infrageniculate bypass is the indication of choice for a lateral approach to the femoral carrefour (10). (Figure 1)

Profunda femoris artery nonstandard approaches

1. Anterior approaches to the middle and distal segment of the profunda femoris artery (Figure 2)

- These techniques permit the approach of the middle or distal profunda femoris artery directly without the incision of the groin. These techniques may be used in the reoperations to avoid a scarred or infectious groin or when the length of autogenous vein graft is limited.
- Direct approach to the middle segment of the profunda femoris artery (anteromedial approach).
The incision is parallel to the medial border of the sartorius muscle (Figure 2,4)

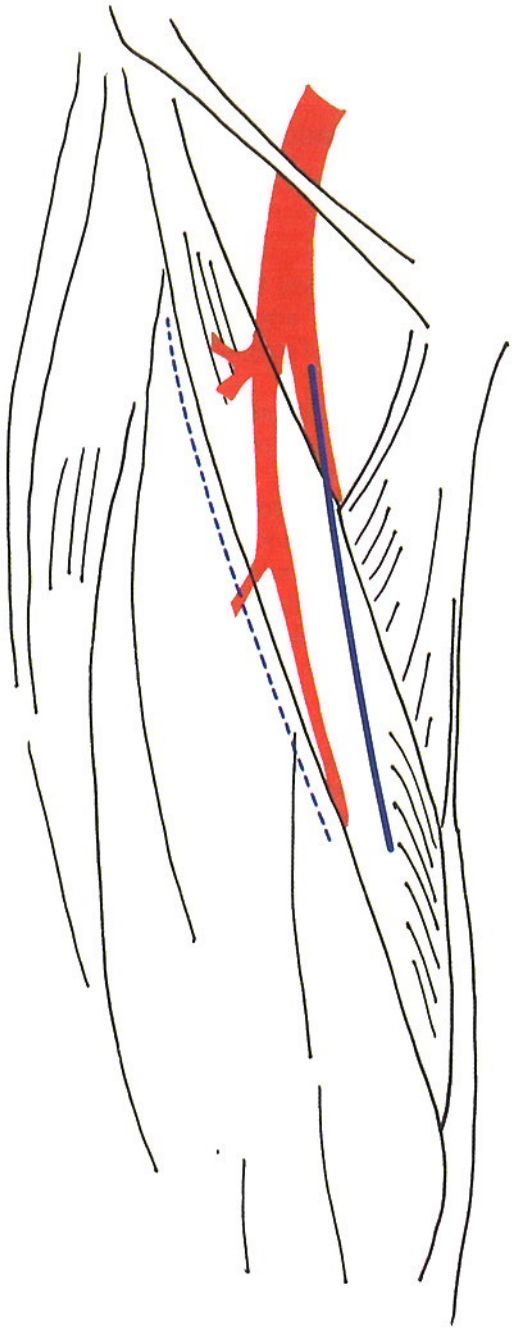


FIGURE 2
Surgical Exposure of the Middle and Distal Segments of the Profunda Femoris Artery. Antero Medial Approach: Solid Line. Antero Lateral Approach: Dashed Line

After the incision is deepened beyond the sartorius muscle, the superficial femoral vascular bundle is mobilized and reflected laterally (5,11).

- Direct approach to the distal segment of the profunda femoris artery (anterolateral approach) (Figure 1,4).
  The incision is parallel to the lateral border of the sartorius muscle.
  After the incision is deepened beyond the sartorius muscle, the superficial vascular bundle is mobilized and reflected medially (5,11).
  This expose the fibrous connection between the sheaths of the adductor longus and vastus medialis muscles. Incision of this fibrous union for several centimetres exposes the underlying profunda femoris artery.
  Profunda femoris artery can be dissected free, taking care to avoid injury to the friable branches that arise from this vessels. If the profunda femoris artery is not pulsatile, it can be located by identifying venous branches deep to the fascial junction of the adductor longus and vastus medialis muscle.

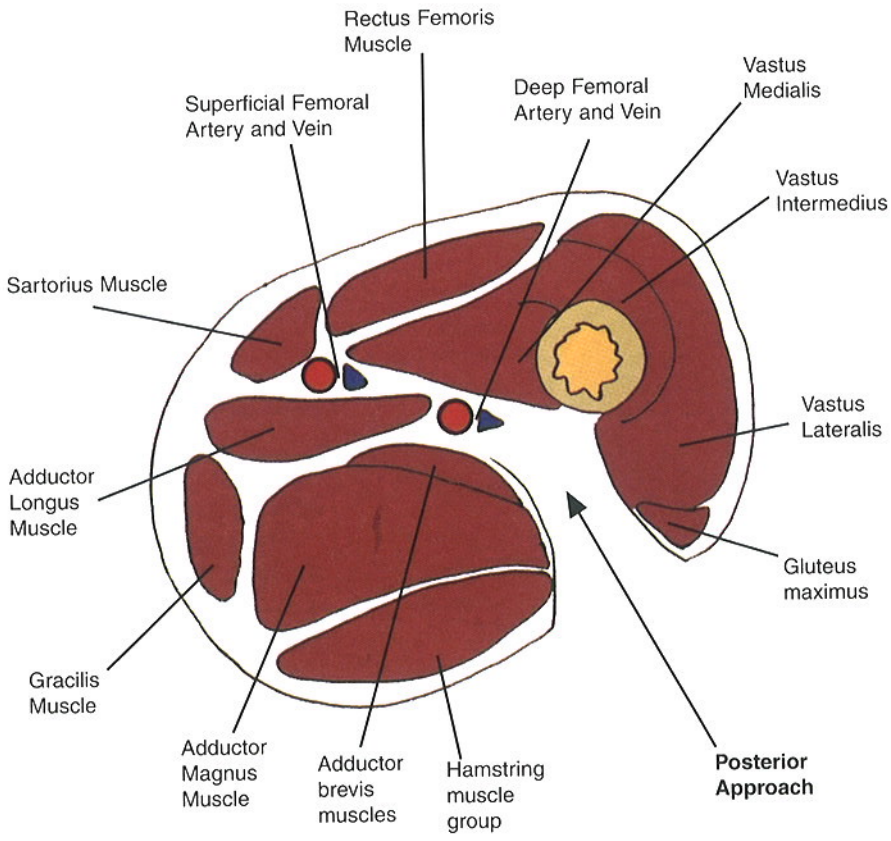


FIGURE 3
Cross section of the thigh displaying exposure of the deep femoral artery via the posterior approach

2. Posterior approaches to the profunda femoris artery

- Posteromedial approach (Figure 4).
  This approach may be utilized in patients who had a previous infection in the subsartorial canal. To facilitate this approach the thigh and the knee of the patient are flexed and the thigh is abducted and externally rotated.
  An incision is made on the medial aspect of the thigh overlying the portion of the profunda femoris artery to be used.
  This incision is deepened posterior the adductor longus muscle and the artery is accessed between this muscle and the adductor brevis muscles (11,12,13).
- Posterior approach (direct exposure of the middle and distal segment) (Figure 3,4).
  The posterior approach to the profunda femoris artery is performed with the patient in the prone position.
  A longitudinal incision is made along a line lateral to the hamstring muscle group, extending approximatively 6 cm. superior and 10 cm. inferior to the gluteal crease.

The inferomedial border of the gluteus maximus is dissected free, allowing for extensive mobilization of the muscle. The gluteus maximus is retracted superolaterally, exposing the superior aspect of the hamstring muscle group.

In addition, the sciatic nerve should be visualized at this time.

The hamstring muscle group is retracted medially in the plane between the biceps femoris and vastus lateralis mucle.

This will expose the adductor magnus muscle to its insertion along the linea aspera of the femur and the perforating branches of the profunda femoris artery.

Mobilization and medial retraction of the sciatic nerve may be required.

The adductor magnus is incised longitudinally by using the perforating branches as a guide to the location of the profunda femoris artery. Finally, the adductor brevis is divided in a similar fashion and the profunda

femoris artery can be identified by its pulsatility or by visualizing accompanying the veins.
This approach exposes the middle and distal segment of the profunda femoris artery (14).

TABLE II
Profunda femoris artery nonstandard approaches

Anterior Approaches	Posterior Approaches
Anteromedial approach	Posteromedial Approach
Anterolateral approach	Posterior Approach

Popliteal artery nonstandard approaches

Combined anterior and posterior approach to the middle segment of the popliteal artery

The indications to bypass grafting to the midpopliteal artery through a posterior incision may be considered when an angiography shows that the supragenicular popliteal artery reconstitutes at or beyond the level at which the femoral condyles flare, but proximal to the knee joint space.

This segment of the popliteal artery may be reached by a classical medial approach, but this approach requires section of the pes anserinus or the medial gastrocnemius muscle (15).

The leg is elevated and the and a vertical incision is made in the proximal popliteal fossa.

After the exposure of the femoral artery at the groin a tunneller is is passed from the popliteal fossa to the groin superficial to the medial head of the biceps and deep to the hamstring muscles along the course of Hunter's canal.

TABLE III
Indication for bypass grafting to the middle segment of the popliteal artery (16)

√ Revascularization after an infected supragenicular graft
√ Patients with an anomalous high tibial artery origin (preferential)
√ Blind popliteal artery
√ Avoidance of prosthetic graft implantation on infragenicular popliteal artery
√ Patients requiring a composite sequential femoropopliteal–tibial bypass graft with PTFE and autologous vein
√ Patient with limited autologous vein length

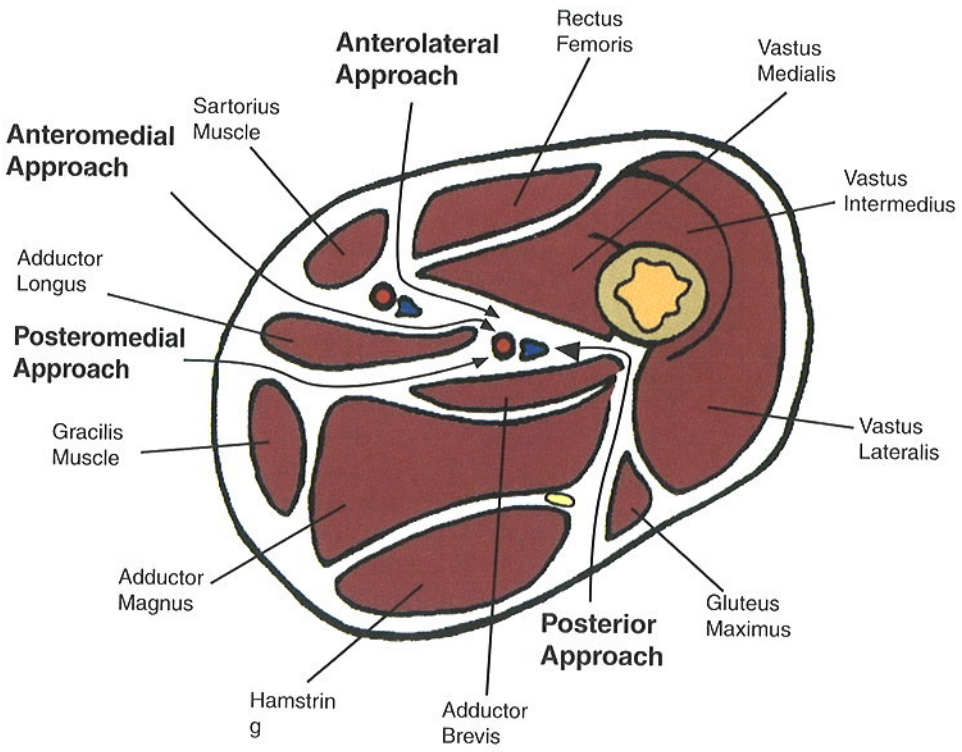


FIGURE 4
Cross Section of the Thigh Displaying Exposure of the Profunda Femoris Artery

The proximal anastomosis are performed and, after the closure of the groin incision, the patient is turned completely prone and the distal anastomosis is performed (16)

Lateral approaches to the popliteal artery

• Above – knee popliteal artery approach.

The popliteal artery above the knee joint may be approached via a lateral incision between the iliotibial tract and the biceps femoris muscle and tendon.

By deepening the incision in the lateral intermuscular septum, the popliteal space can be entered and the neurovascular bundle palpated within the popliteal fat. The popliteal artery is easily isolated from the adjiacent popliteal vein or veins, taking care not to injure

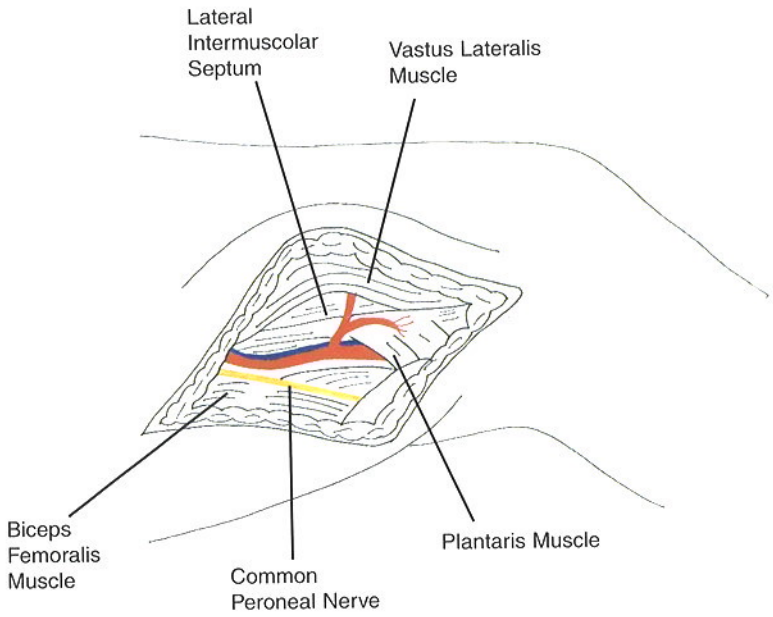


FIGURE 5
Above-knee Popliteal Lateral Approach

the common peroneal nerve. After the popliteal artery is dissected from these structures, gentle traction with vessel loops can elevate it close to the skin level where an anastomosis, can be performed (17,18). (Figure 7)

• Below – knee popliteal artery approach.

This segment of the popliteal artery is approached via lateral incision over the head and proximal fourth of the fibula.

This incision is deepened through the subcutaneous tissue and superficial muscular attachments to the fibula, taking care to identify the common peroneal nerve as it course around the neck of this bone.

This nerve is dissected free so that it can be retracted and protected from injury.

The biceps femoris tendon is divided. The ligamentous attachments of the fibula are incised and the upper fourth of the fibula is freed bluntly from its muscular and ligamentous attachments, staying as close to the bone possible.

After a retractor is placed deep to the fibula to protect underlying structures, the bone is transacted at the its proposed site.

With the entire upper fibula removed, the entire below-knee popliteal artery, the tibioperoneal trunk, the anterior tibial artery and the origins of the peroneal and posterior tibial arteries lie just deep to the excised bone and can be dissected free from their adjacent veins.

To conduct the graft to or from a popliteal artery laterally approached, tunnels are performed in a subcutaneous plane.

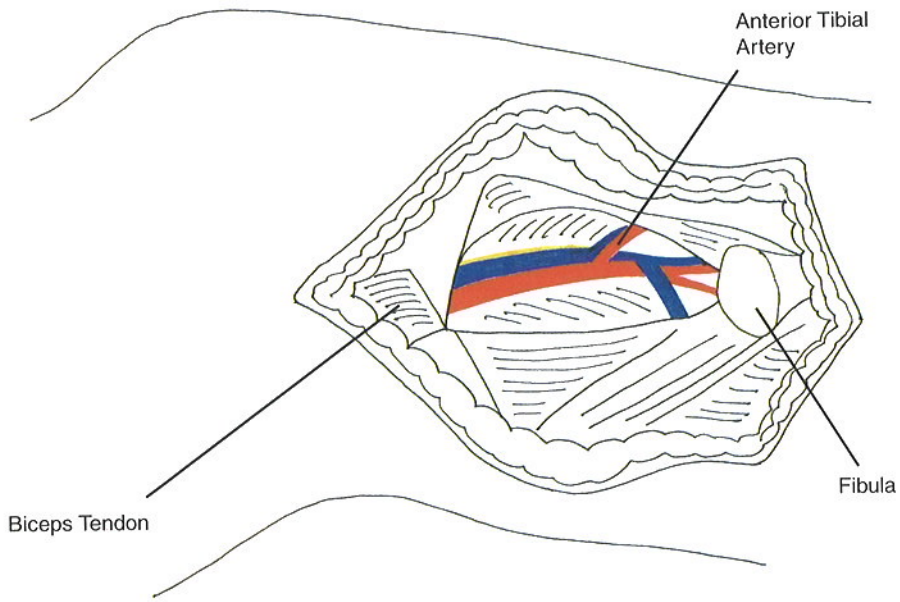


FIGURE 6
Below-knee Popliteal Artery Lateral Approach

For grafts from the femoral arteries approached via a standard groin incision, the course should be cross the anterior aspect of the midthigh and then down the lateral aspect of the lower thigh to the popliteal fossa.

If the external iliac artery, the axillary artery, or the thoracic aorta are used as inflow, the tunnel follows a curve from the inflow artery to the lateral aspect of the thigh and then inferiorly to the popliteal fossa (11,17,18).

Descending artery of the knee approach

Through a medial supracondylar approach, the saphenous nerve was found emerging from the fascia of the femoral canal. Following the division of the fascia, the descending artery of the knee is traced to its origin on the femoral artery (19).

Crural arteries nonstandard approaches

Medial approach to the anterior tibial artery (Figure 7)

The incision is performed medially to allow access to the saphenous vein and to avoid additional incisions for its mobilization.

After the deep fascia is incised and subcutaneous fasciotomy is performed, the soleus muscle is reflected posteriorly.

The posterior tibial neurovascular bundle can be identified and the plane entered anterior and posterior tibial muscle.. In the lower third of the leg, it may be easier to dissect anterior to the flexor digitorum tendon and muscle with the origin of the latter taken off the tibia. The posterior tibial muscle is also dissected away from the tibia and interosseus membrane. The interosseus membrane is then identified deep within the wound and is incised. The tibial vessels are identified just behind the incised membrane and can be brought into the field by pressure on the leg against the anterolateral compartment. (20)

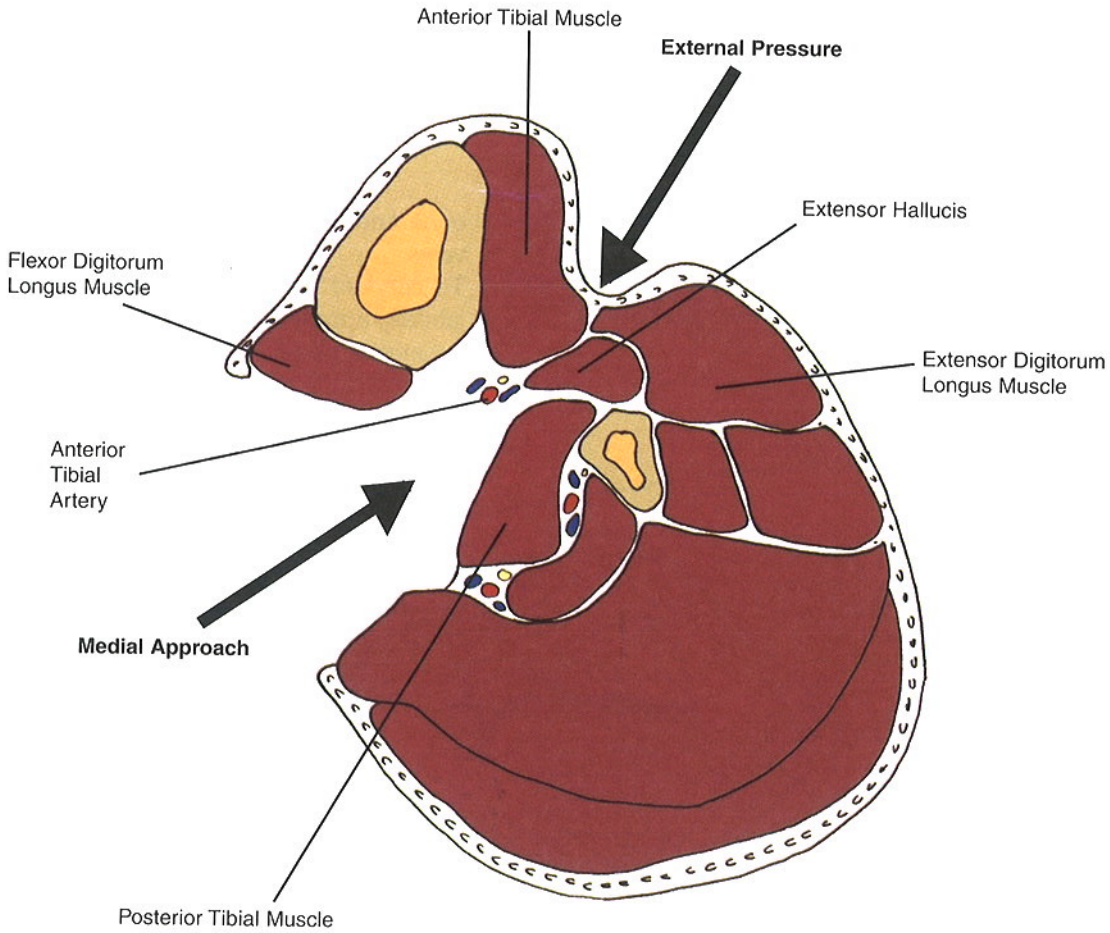


FIGURE 7
Medial Approach to the Anterior Tibial Artery

Posterior tibial artery approach (Figure 8).

The posterior investing deep fascia of the calf is incised longitudinally, medial to the bulk of tendo calcaneus within the distal one third of the calf.

The posterior tibial artery is readily encountered as it coursed along the surface of the coronal septum dividing the deep and the intermediate subcompartiments of the posterior tibiofibular compartiment (21). The artery runs posterior to the flexor digitorum longus muscle at a level approaching the malleoli, requiring medial retraction of the muscle to expose the distal portion of the artery (22).

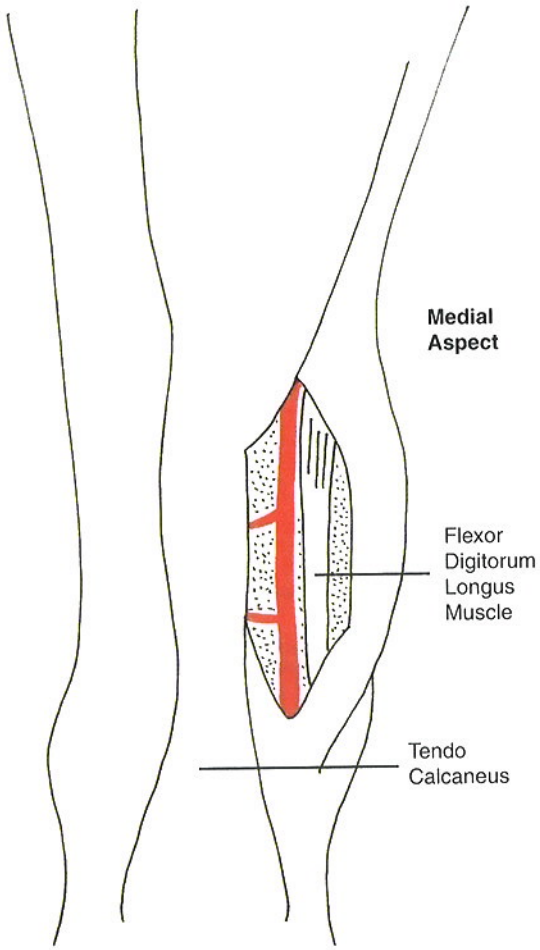


FIGURE 8
Exposure of the posterior tibial artery through posterior approach

Peroneal artery approach (Figure 9)

The investing deep fascia is incised longitudinally, lateral to tendo calcaneus.

The flexor hallucis long muscle was reflected laterally and, as in the medial tecnique of peroneal exposure, the fibula is palpated as a landmark running immediately lateral to the artery.

The vessel may be exposed over a distance of up 15 cm before it bifurcates into anterolateral and posteromedial collateral branches running to the anterior and posterior tibial arteries respectively (23).

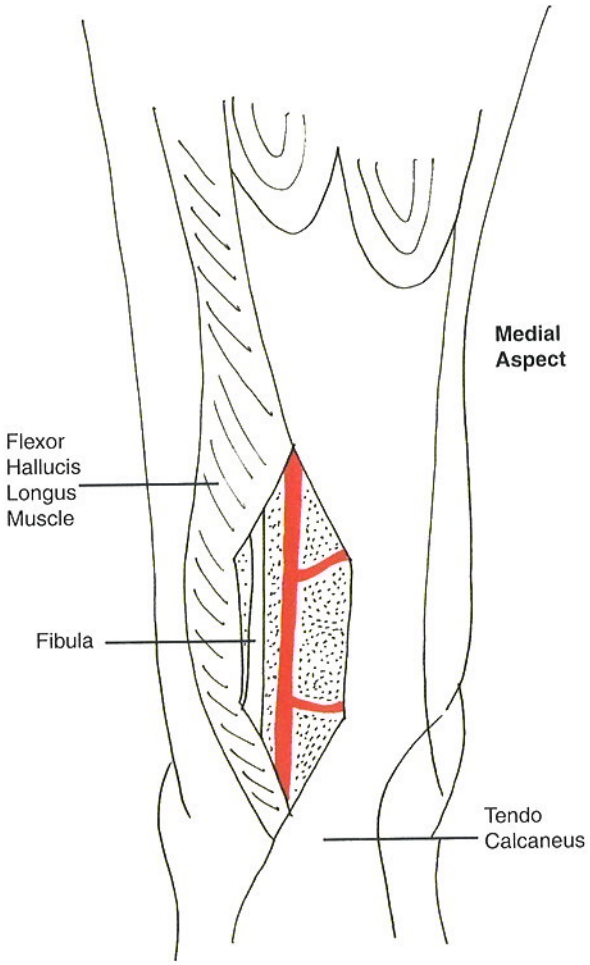


FIGURE 9
Exposure of the peroneal artery through posterior approach

Anterior tibial artery approach

The distal anterior tibial artery cannot be easily exposed through the lesser saphenous vein harvest incision.

Nevertheless, the vessel is approached through an incision identical to that used in standard technique.

The leg is externally rotated to bring the cleft between the anterior tibial and extensor hallucis longus muscle into an accessible orientation (23).

Inframalleolar arteries approaches

Lateral and medial plantar branches approach

The lateral plantar artery ends in the main or deep plantar arch and it is usually larger than its medial counterparts.

The medial branch gives off small collateral vessels to the intrinsic muscle of the first, second and third toes. The skin incision is made long to permit exposure of the retromalleolar portion of the posterior tibial artery.

It extends inferiorly and laterally onto the sole of the foot.

After the posterior tibial artery is isolated, the dissection is extended across the sole of the foot.

The lateral plantar branch is located inferiorly when the foot is externally rotated on the operating table. Exposure of the proximal 2 to 3 centimetres of the plantar branches is achieved by incision of the flexor retinaculum or lacinate ligament and transection of the abductor hallucis muscle (24,25) (Figure 10a, 10b, 11).

Deep plantar or deep metatarsal arch branches approach

The deep plantar branch is the extension of the dorsalis pedis artery. It originates at the metatarsal level where it descends into a foramen bounded proximally by the dorsal metatarsal ligament, distally by the dorsal interosseus muscle ring and medially and laterally by the base of the first and second metatarsal bones.

A longitudinal incision over the dorsum of the mid portion of the foot permits the dissection of the dorsalis pedis artery down to its bifurcation into the deep plantar and the first dorsal metatarsal branches.

The extensor allucis brevis muscle is retracted laterally or transacted and the dorsal interosseus muscle ring is split to allow better exposure of the proximal portion of the deep plantar branch.

The second metatarsal bone is then resected to allow for optimal exposure (24,25) (Figure 12a,b).

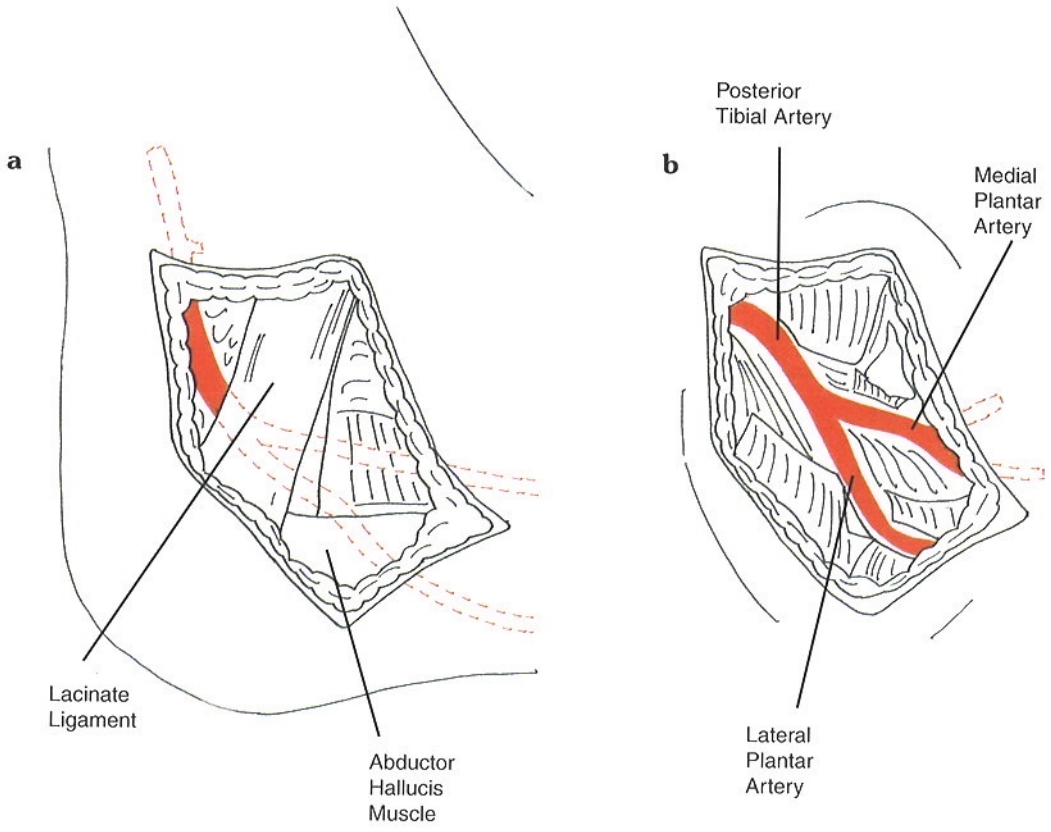


FIGURE 10a,b
Surgical Approach of the Lateral and Medial Plantar Branches of the Posterior Tibial Artery

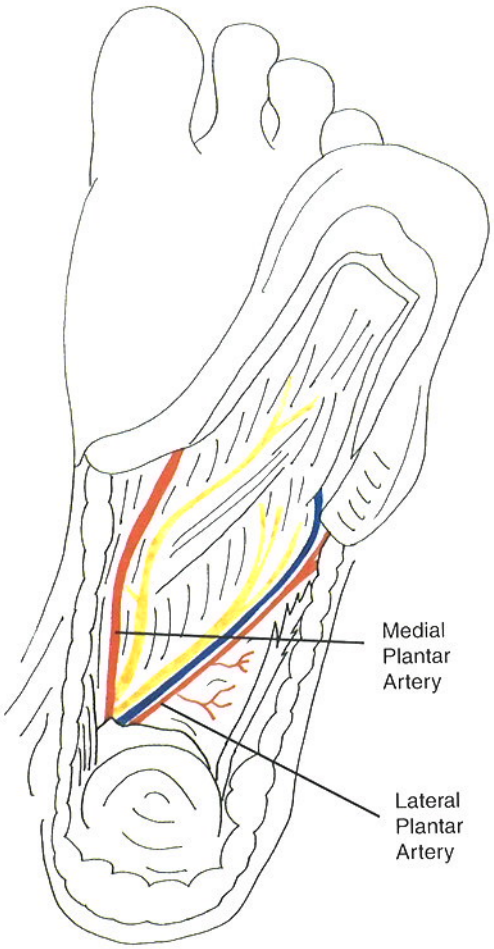
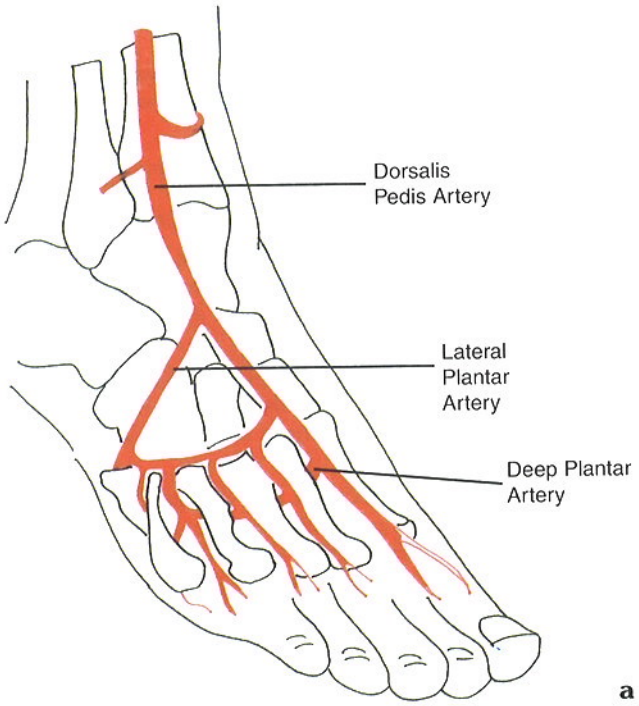


FIGURE 11



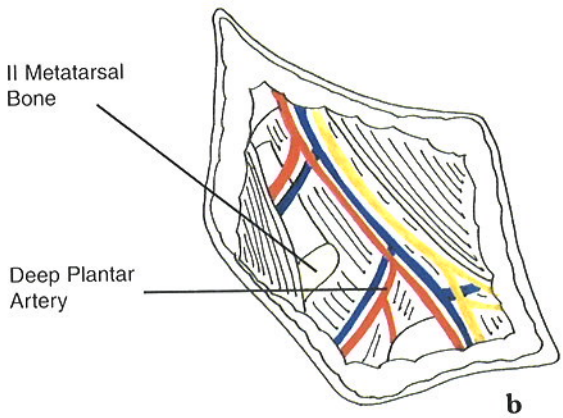


FIGURE 12a,b
Surgical Exposure of the Deep Plantar Artery After Resection of the II Metatarsal Bone

Lateral tarsal branch approach

The lateral tarsal artery originats from the dorsalis pedis artery at the level of the navicular bone and runs laterally toward the fifth metatarsal bone under the short extensor muscle of the toes. This branch is an important source of blood supply to the dorsal aspect of the foot and anastomoses with the arcuate artery (Figure 12a).

The dorsalis pedis artery is dissected at the level of the ankle joint after division of the inferior extensor retinaculum.

Dissection must be continued distally to the origin of lateral tarsal branch.

Further mobilization of the latter artery can be achieved by lateral retraction of the long extensor tendons of the toes and partial incision of the short extensor muscle of the great toe (24,25).

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