Thieme

Anatomy of the arteries of the lower limb

Anatomie der Arterien: Untere Extremität

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ABSTRACT

Anatomy of the vessels of the human body, their morphology and haemodynamics are integral elements of vascular medicine. Specifically, a dedicated knowledge of the vessel anatomy is essential for a correct diagnosis and further diagnostic and therapeutic procedures. This article shows the course of the arteries of the lower limb in relation to the bones, their projection to the skin, the positioning of the ultrasound probe and the normal findings in plain ultrasound as parallel images.

ZUSAMMENFASSUNG

Anatomie, Morphologie und Hämodynamik sind elementare Bausteine der Gefäßmedizin. Insbesondere die Kenntnis der Anatomie der Arterien der unteren Extremität ist für weiterführende diagnostische Maßnahmen wie die farbkodierte Duplexsonografie von großer Bedeutung. Der vorliegende Artikel zeigt pragmatisch in parallelen Bildern den anatomischen Verlauf der Beinarterie zum Skelett, die Projektion der Anatomie auf die Haut mit der erforderlichen Schallkopfführung und den sonografischen Normalbefund.

The importance of an accurate knowledge of vascular anatomy is evident by from the high prevalence of pathological processes in the arteries of the lower limb. More than 50 % of stenotic lesions in the vessels, usually atherosclerotic in origin, are to be found in the leg arteries [1]. This article presents ultrasound scans in conjunction with a visualisation of the course of the blood vessels on the surface of the skin (▶ **Fig. 1**) to give a better understanding of the anatomy of the arteries of the lower limb [2–4].

Aortic bifurcation

The vascular supply of the lower limb starts with the division of the abdominal aorta into the right and left common iliac trunks (*Aa. iliacae communes dextra* and *sinistra*) at the level of the fourth lumbar vertebra (▶ **Fig. 2**).

Pelvic arteries

Common iliac artery (Arteria iliaca communis)

The common iliac artery has a diameter 7–12 mm it is covered by the parietal peritoneum and runs laterally and distally along the medial edge of the psoas major muscle without giving off any significant branches (▶ **Fig. 3**).

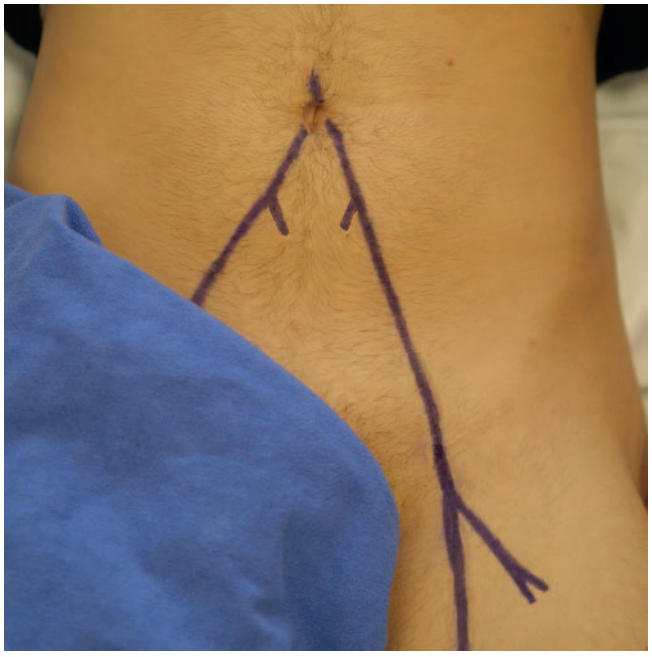
The right common iliac artery crosses over the start of the inferior vena cava (*V. cava inferior*) and the common iliac veins (*Vv. iliacae communes*). The left common iliac artery runs anterior and lateral to the left common iliac vein. The common iliac arteries can vary between 2 cm and 8 cm in length.

At the level of the sacroiliac joint, the common iliac artery divides into the external and internal iliac arteries.

PLEASE NOTE
The diameter of the artery decreases from proximal to distal. A positive correlation has been described between the vessel diameter and body surface area and increasing age. [5]

Internal iliac artery (Arteria iliaca interna)

Parietal and visceral branches of the internal iliac artery (diameter 4–7.5 mm supply structures in the pelvic wall and sacral canal, the buttocks, the inner aspect of the thigh, the pelvic floor, the external genitalia and the anal canal (▶ **Fig. 4**).



▶ **Fig. 1** Projection of the course of the aorto-iliac-femoral axis in the left lower abdomen. The anatomical position of the left iliofemoral vessels, as determined by ultrasound, has been projected onto the skin and shown by the coloured line. At its bifurcation, the aorta divides into the right and left common iliac arteries (*Aa. iliacae communes*). After the origin of the internal iliac artery (*A. iliaca interna*), the external iliac artery (*A. iliaca externa*) passes beneath the inguinal ligament and continues as the common femoral artery (*A. femoralis communis*).

Externa iliac artery (Arteria iliaca externa)

The external iliac artery, a large calibre vessel (diameter between 5–10 mm), first continues the course of the common iliac artery on the medial edge of the iliopsoas muscle (▶ **Fig. 5**).

In its subsequent course in a distal direction, the external iliac artery reaches the anterior aspect of the muscle through the vascular lacuna and becomes the common femoral artery (*A. femoralis communis*). Before entering the vascular lacuna, it gives off the inferior epigastric artery (*A. epigastrica inferior*) and the deep circumflex iliac artery (*A. circumflexa iliaca profunda*).

PLEASE NOTE

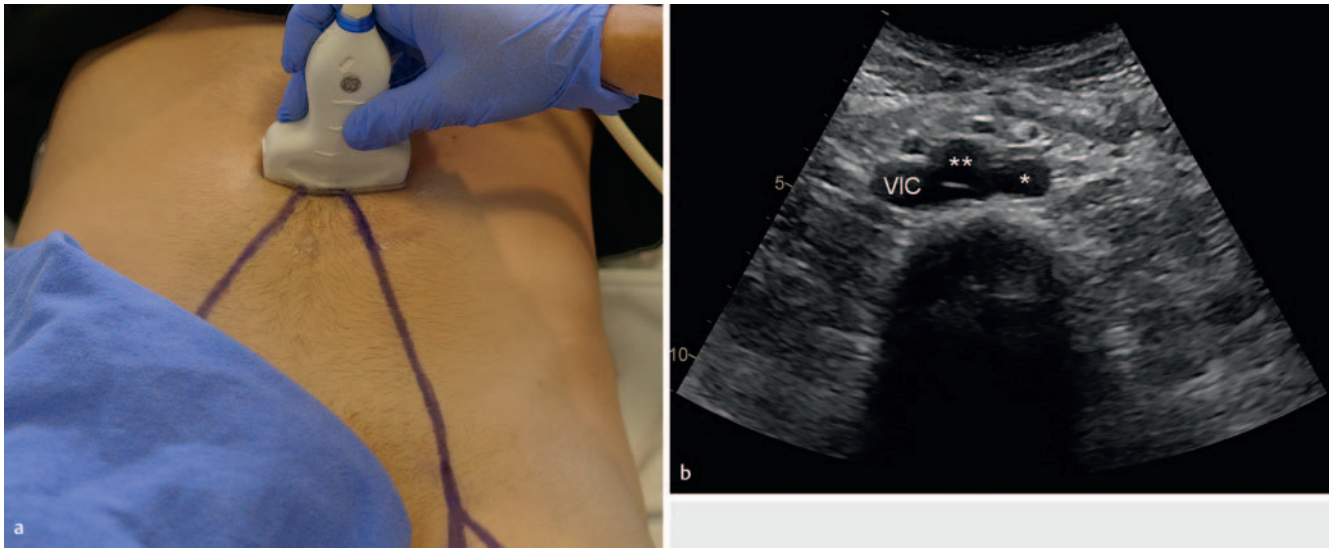
Looking for the pelvic arteries is often easier by following the course of the external iliac artery upwards above the inguinal ligament. Tilting the probe laterally allows the origin of the internal iliac artery to be demonstrated.

In the groin

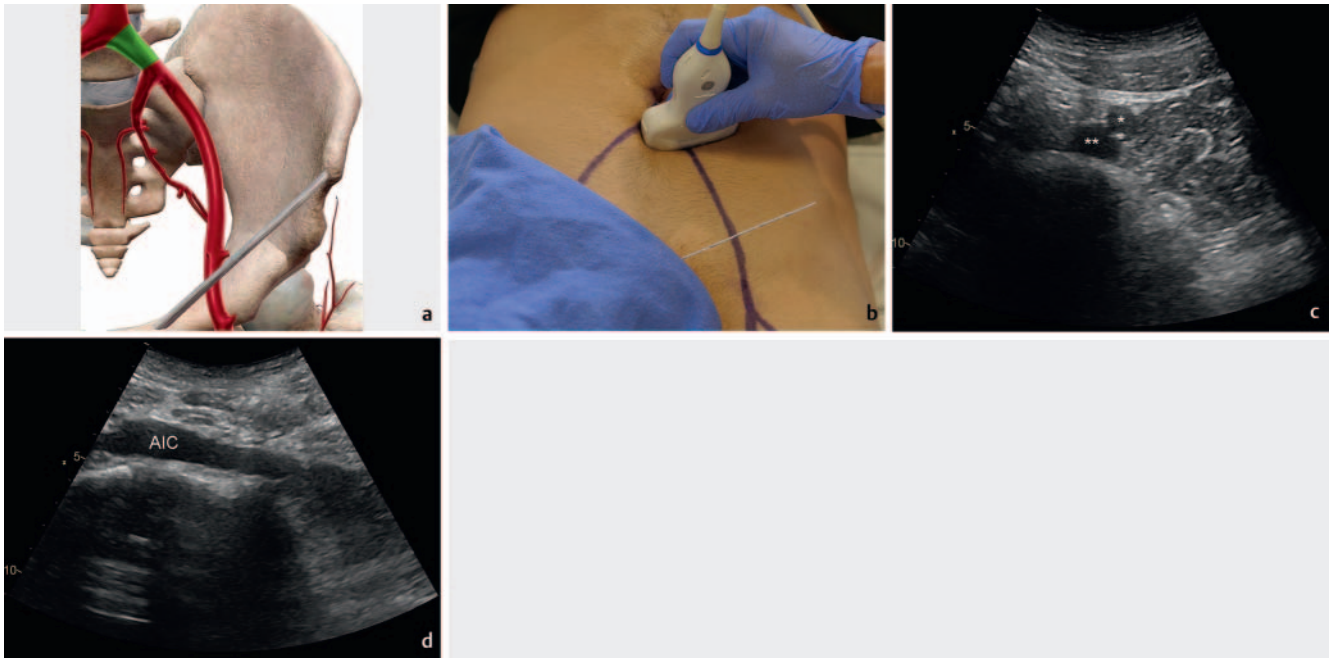
The main blood vessels and nerves supplying the lower limb pass through the vascular lacuna and the muscular lacuna to reach the anterior of the leg as well as leaving the pelvis through the obturator canal on the medial aspect.

Arteries of the legs

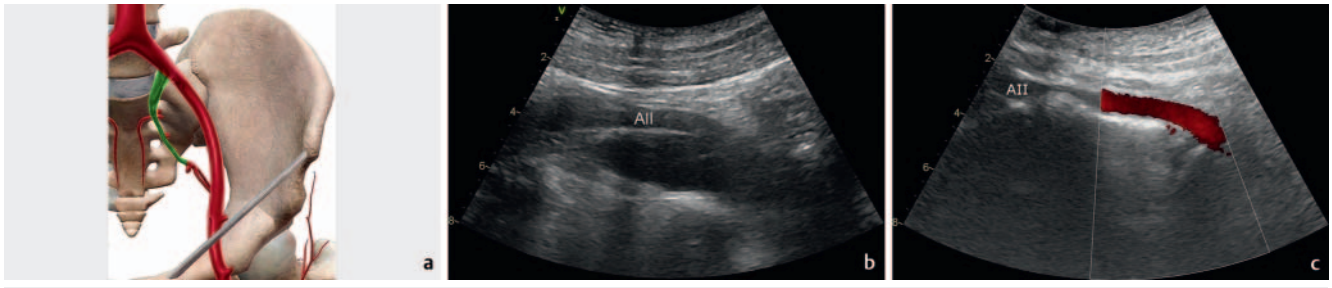
Distal to the inguinal ligament, the common femoral artery is the continuation of the external iliac artery. Branches of the common



▶ **Fig. 2** Aortic bifurcation. **a** Position of the ultrasound probe just above the umbilicus. **b** Transverse section through the bifurcation of the aorta. * left common iliac artery, ** right common iliac artery, VIC = right common iliac vein (*V. iliaca* communis).



▶ **Fig. 3** Common iliac artery (*A. iliaca* communis, AIC). **a** Illustration showing the anatomy of the pelvic vessels with the left common iliac artery shown in green. **b** Position of the probe to identify the left common iliac artery. The grey line shows the position of the inguinal ligament. **c** Transverse section through the left common iliac artery. *common iliac artery, **common iliac vein. **d** Longitudinal section through the left common iliac artery.



▶ **Fig. 4** Internal iliac artery (*A. iliaca interna*, AII). **a** Schematic anatomical representation of the left internal iliac artery, shown in green. **b** Internal iliac artery seen in its longitudinal axis. **c** Colour-coding of the same B-mode image to clarify the position of the vessel.

femoral artery form the arteries supplying the thigh, lower leg and foot. The deep femoral artery, also known as the profunda femoris, supplies the proximal end of the femur, the femoral shaft, the hip joint and the majority of the thigh muscles. Arteries branching from the superficial femoral artery supply the knee, lower leg and foot.

Common femoral artery (Arteria femoralis communis)

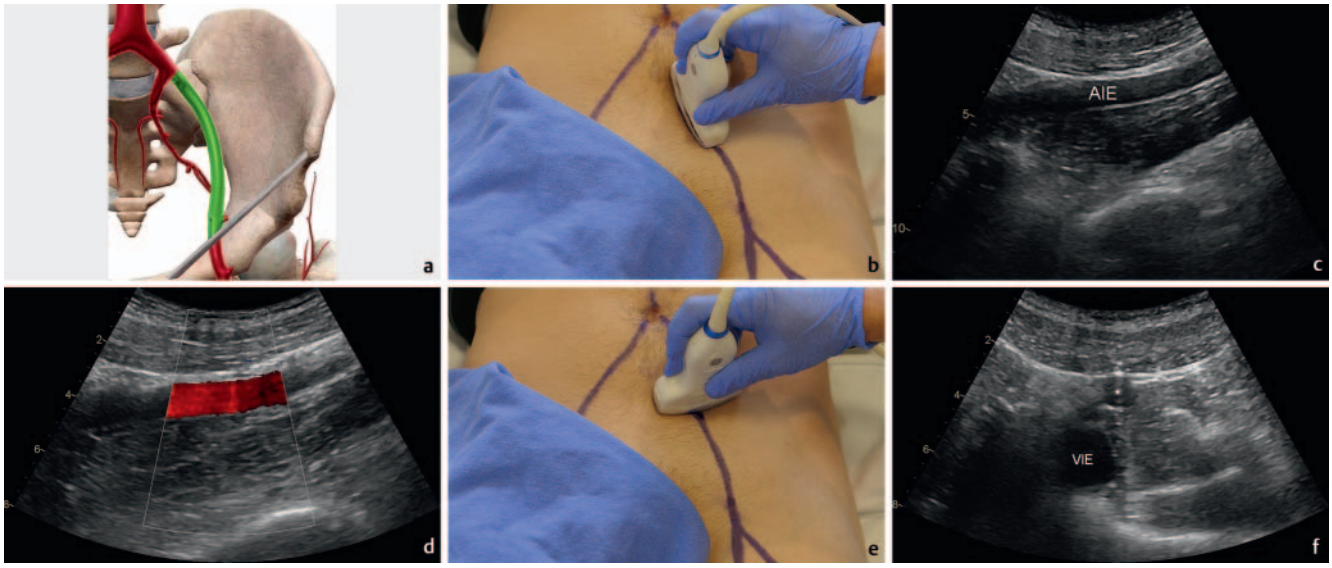
With a diameter of 5–7 mm, the common femoral artery runs distally between the iliopsoas and pectineus muscles, lying lateral to the correspondingly named vein (▶ **Fig. 6**), and divides into the superficial femoral artery and the deep femoral artery (▶ **Fig. 7, 8**).

The level of the femoral bifurcation may show great variation. In some cases, the femoral bifurcation may be situated very proximally, close to the inguinal ligament.

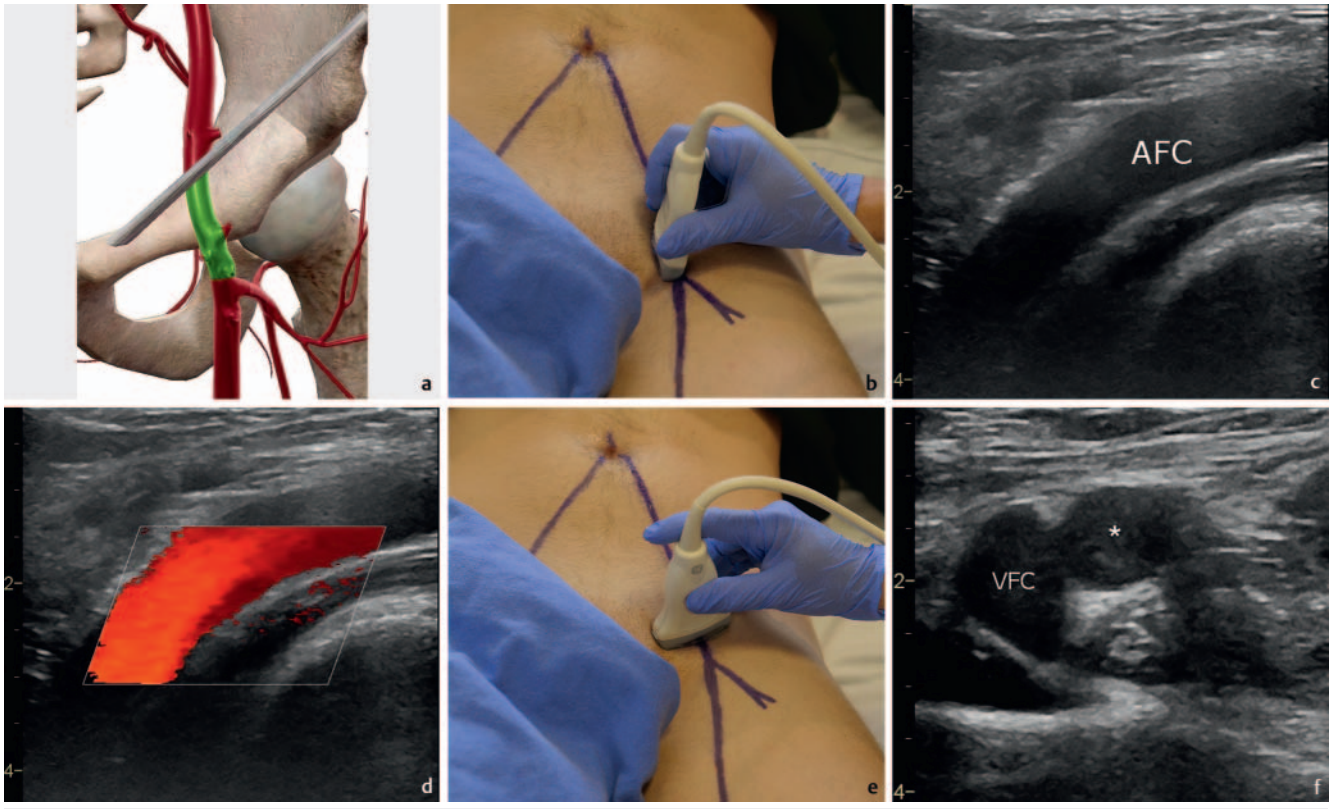
Deep femoral artery (Arteria profunda femoris)

The deep femoral artery is also known as the profunda femoris. It usually originates from the common femoral artery some 3–6 cm below the inguinal ligament and runs posterolaterally (▶ **Fig. 9**).

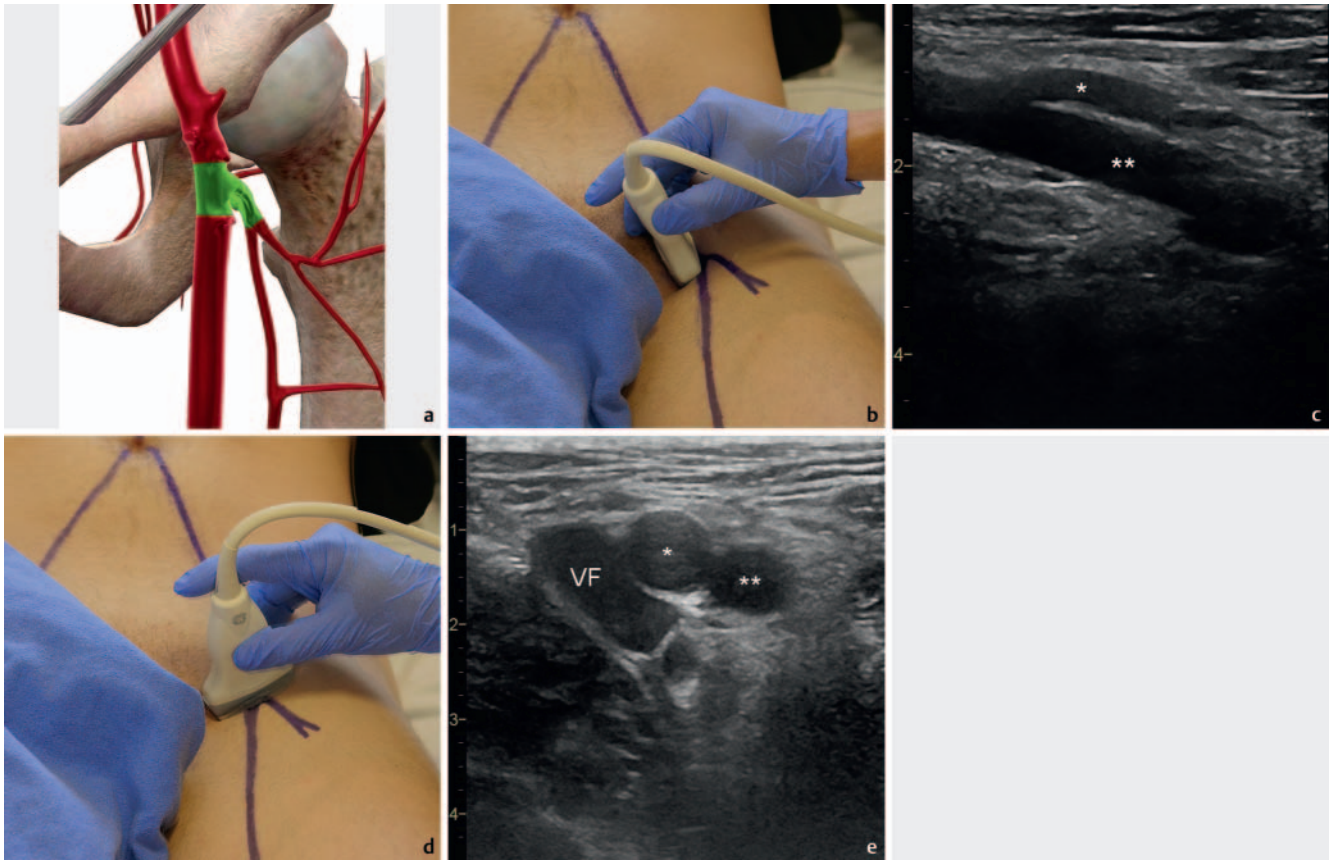
The deep femoral artery supplies a large part of the structures in the thigh. The artery lies lateral or posterior to the superficial femoral artery and runs behind the superficial femoral vessels to the medial side of the femur, where it passes between the adductors and vastus medialis muscle to reach deeper into the tissues. Distal to the femoral bifurcation, the medial circumflex femoral artery (*A. circumflexa femoris medialis*) usually arises from the deep femoral artery and runs towards the medial side of the neck of the femur (▶ **Fig. 8c**).



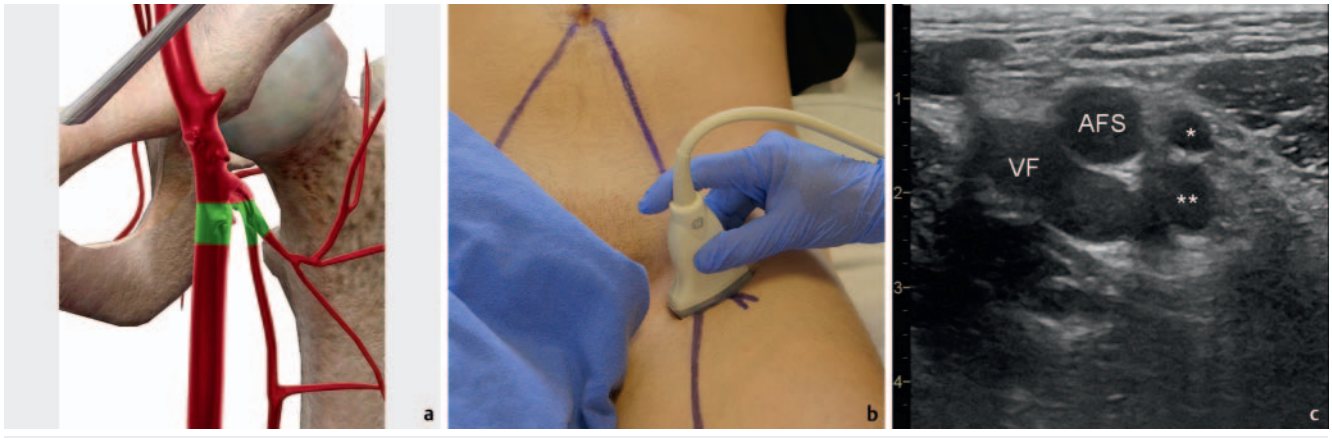
▶ **Fig. 5** External iliac artery (*A. iliaca externa*, AIE). **a** Schematic anatomical representation of the left external iliac artery, shown in green. **b** Position of the probe longitudinal to the external iliac artery. **c** Corresponding B-mode image of the external iliac artery. **d** Additional colour coding of a segment of the external iliac artery. **e** Corresponding position of the probe in cross-section. **f** B-mode image of the external iliac artery with the probe in this position. * external iliac artery, VIE = external iliac vein (*V. iliaca externa*).



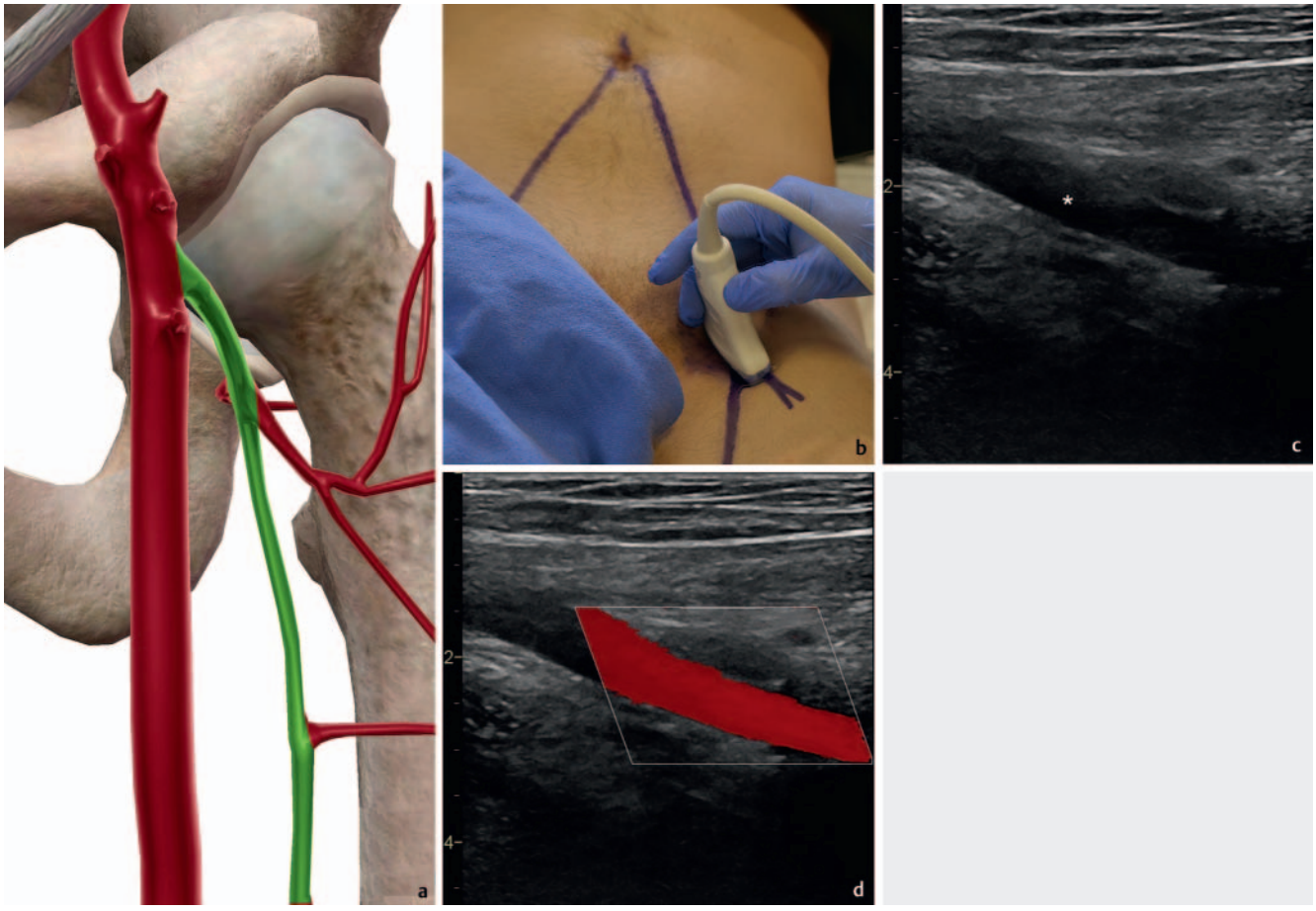
▶ **Fig. 6** Common femoral artery (*A. femoralis communis*, AFC). **a** Anatomical representation of the femoral vessels with the left common femoral artery shown in green. **b** Position of the common femoral artery with the transducer in longitudinal section. **c** Corresponding B-mode image of the common femoral artery with **d** colour coding. **e** Position of the common femoral artery in transverse section and **f** corresponding B-mode image, showing the common femoral artery (*) and accompanying common femoral vein (*V. femoralis communis*, VFC).



▶ **Fig. 7** Femoral bifurcation. **a** The figure shows the anatomy of the bifurcation of the common femoral artery into the superficial and deep femoral arteries (shown in green) immediately after the inguinal ligament. **b** Position of the probe to identify the common femoral artery in longitudinal section. **c** Corresponding B-mode image showing the take-off of the deep femoral artery (*) and continuation of the vessel as the superficial femoral artery (**). **d** The corresponding transverse section with the position of the probe and **e** the B-mode image showing the deep femoral artery (*) and the superficial femoral artery (**), as well as tributaries of the femoral vein (VF).



▶ **Fig. 8** Positions of the superficial and deep femoral arteries in the groin, just below the left femoral bifurcation. **a** Femoral vessels shown in green in the diagram. **b** The position of the probe to give **c** a B-mode image showing the superficial femoral artery, the accompanying vein and the deep femoral artery (**) as well as the first arterial branch – the medial circumflex femoral artery (*A. circumflexa femoris medialis*) (*).



▶ **Fig. 9** Profunda femoris artery or deep femoral artery (*A. profunda femoris*, APF). **a** Diagram showing the anatomical position of the left deep femoral artery (highlighted in green). **b** Slightly tilting the probe makes it easier to demonstrate the deep femoral artery. **c** B-mode image showing the deep femoral artery; **d** Colour coding emphasises the course of the vessel.

Superficial femoral artery (Arteria femoralis superficialis)

The superficial femoral artery is the continuation of the common femoral artery and runs in the groove between the vastus medialis and adductor longus muscles, accompanied by the femoral vein, to the distal end of the femoral triangle (▶ **Fig. 10**).

In the middle of the thigh, the superficial femoral artery runs in the adductor canal. Its diameter is 4–7 mm. The superficial femoral artery becomes the popliteal artery when it exits the adductor canal through the adductor hiatus in the posterior thigh.

PLEASE NOTE

In ultrasound scans of the thigh, the accompanying femoral vein always lies below the artery and can be compressed.

Popliteal artery (Arteria poplitea)

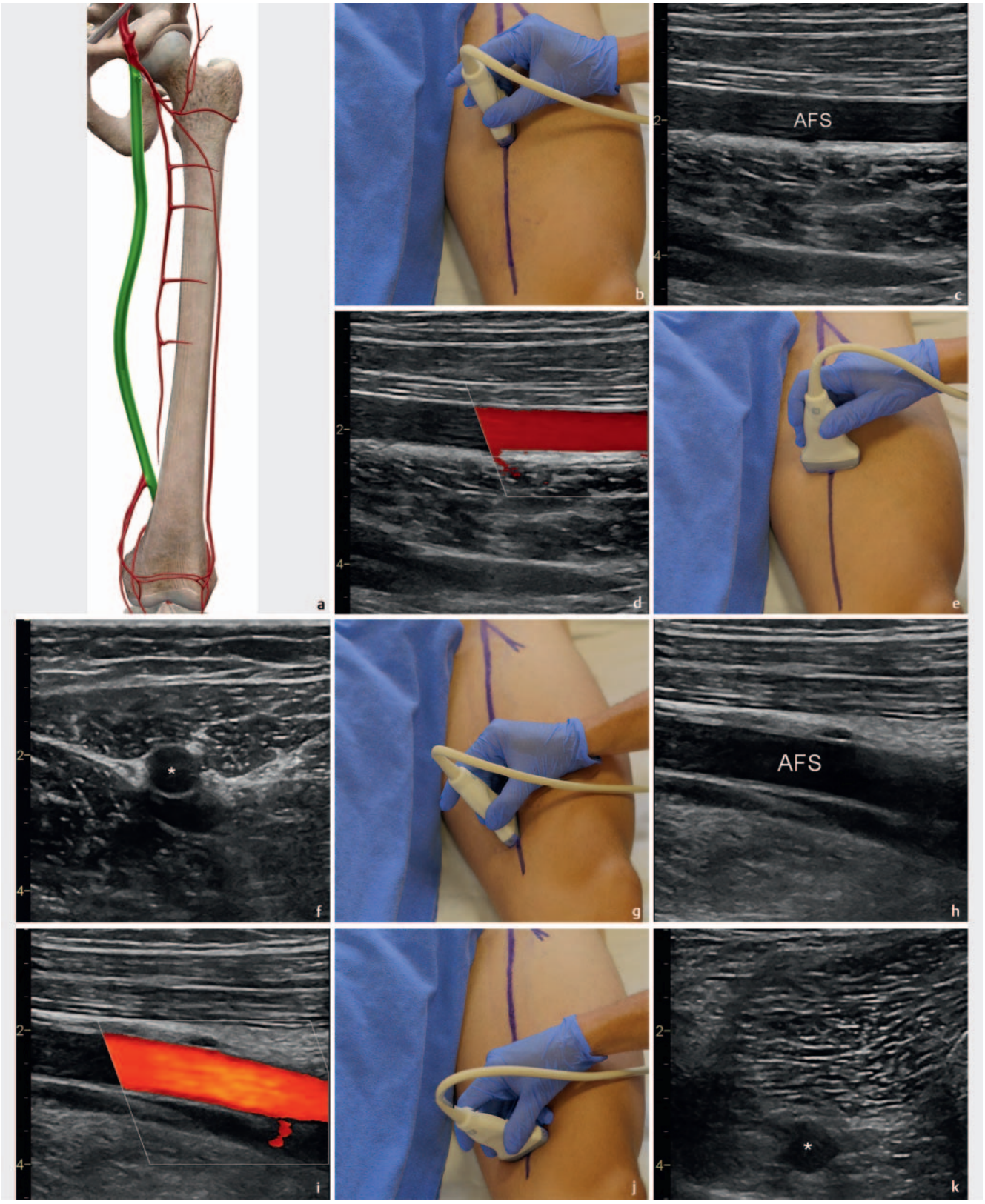
Anatomically speaking, the popliteal artery is the continuation of the superficial femoral artery from the end of the adductor canal (▶ **Fig. 11**).

The artery runs distally from the adductor canal to the middle of the popliteal fossa. It is some 15–20 cm long and 4–6 mm in diameter. It supplies adjacent muscles, the knee joint and the skin. Clinically, the popliteal artery is divided into three segments. The first segment runs to the upper edge of the patella (P1 segment). The transition from P2 to P3 occurs at the level of the knee joint space, after which the third segment extends to the origin of the anterior tibial artery (▶ **Fig. 11**).

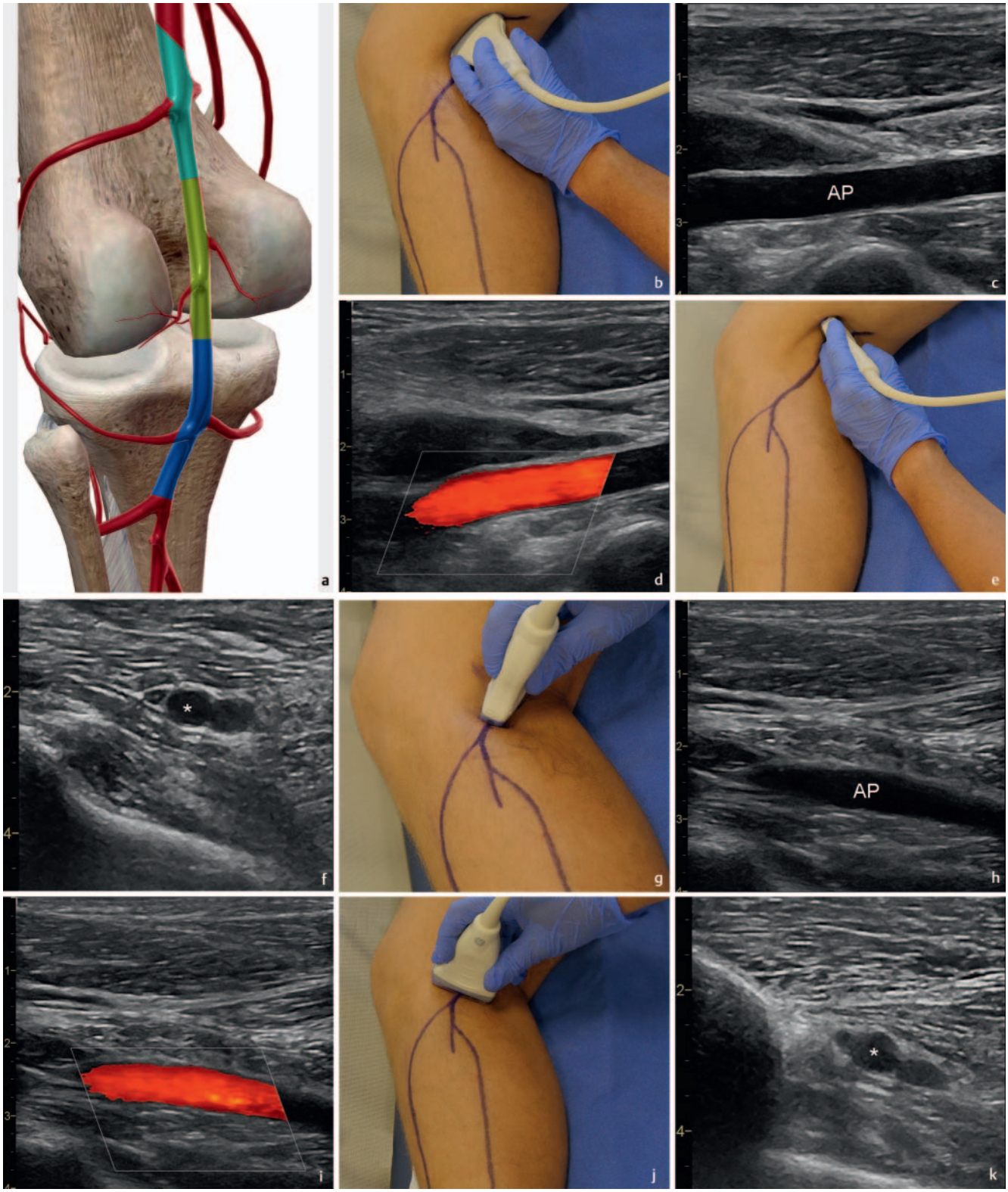
The popliteal artery gives off the sural arteries (*Aa. surales*), robust muscle branches that arise from the middle segment of the popliteal artery and penetrate the heads of the gastrocnemius muscle. The knee joint is usually supplied by five branches of the popliteal artery, forming the periarticular arterial network known as the genicular anastomosis (*rete articulare genus*).

PLEASE NOTE

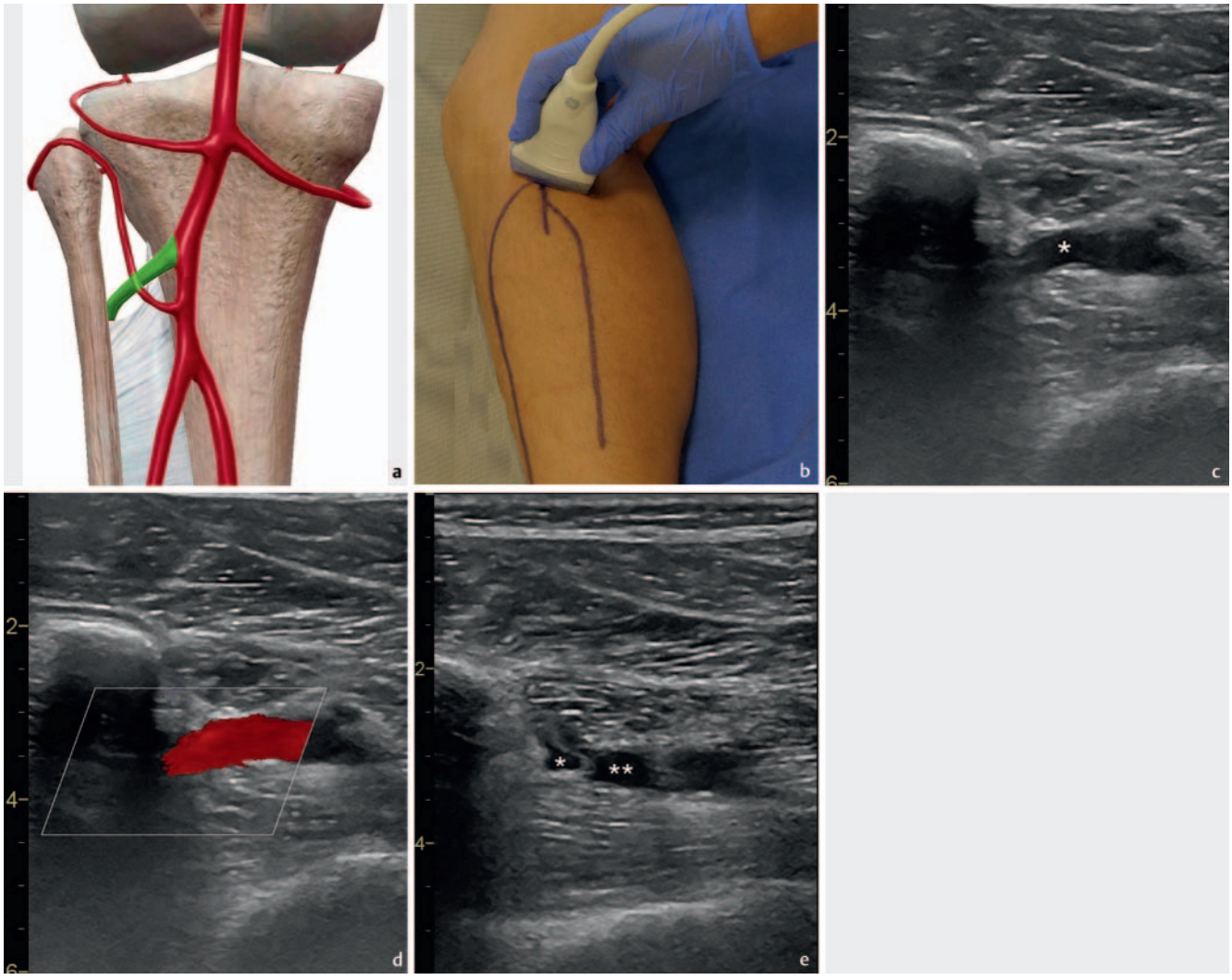
The popliteal vessels can be examined with the patient lying supine with the leg raised and the knee bent, lying in the lateral position or sitting. Scanning in the transverse plane usually identifies a vein lying above the popliteal artery.



▶ **Fig. 10** Superficial femoral artery (*A. femoralis superficialis*, AFS). **a** Anatomical course of the superficial femoral artery in the left thigh shown in green. **bb** The position of the probe in longitudinal section produces **c** a B-mode image with clear demonstration of the superficial femoral artery. **d** Colour-coding highlights the course of the vessel. **e** Rotating the probe through 180° gives a transverse view of the common femoral artery (*) with **f** the accompanying vein lying directly beneath. **g** Moving the probe further distally in a medial direction demonstrates the superficial femoral artery shortly before it becomes the popliteal artery **h** in B-mode and **i** with additional colour-coded highlighting. **j** Transverse rotation in this position shows **k** the superficial femoral artery (*) running deeper into the tissues.



▶ **Fig. 11** Popliteal artery (*A. poplitea*, AP). **a** Diagram of the anatomy of the popliteal artery, with the clinically relevant segments shown in different colours: P1 (green), P2 (yellow) and P3 (blue). The popliteal artery can be found from behind the popliteal fossa with the patient lying in the lateral position. **b** Position of the probe to detect the proximal popliteal artery (P1) in longitudinal section with **c** the B-mode scan and **d** the duplex ultrasound image. **e** Corresponding position of the probe for the transverse section with **f** the B-mode scan. The popliteal artery (*) is accompanied by two veins.



▶ **Fig. 12** Anterior tibial artery (*A. tibialis anterior*, ATA). **a** Shown in green is the proximal course of the left anterior tibial artery starting at its origin from the popliteal artery until it passes through the gap in the interosseous membrane in the lower leg. **b** The figures show the anterolateral position of the probe to examine the vessel's origin; the transverse B-mode image of the outflowing anterior tibial artery (*) with colour-coded highlighting of the vessel's course for better recognition and the B-mode image of the anterior tibial artery (*) in transverse section directly after it branches from the popliteal artery (**).

The popliteal artery, which lies on the bony floor of the popliteal fossa, divides into the arteries of the lower leg, the anterior tibial and posterior tibial arteries, at the lower edge of the popliteus muscle (▶ **Fig. 12**).

PLEASE NOTE

The distal popliteal artery, also designated the P3 segment, can most easily be seen in the proximal medial lower leg, with two accompanying veins (*venae comitantes*).

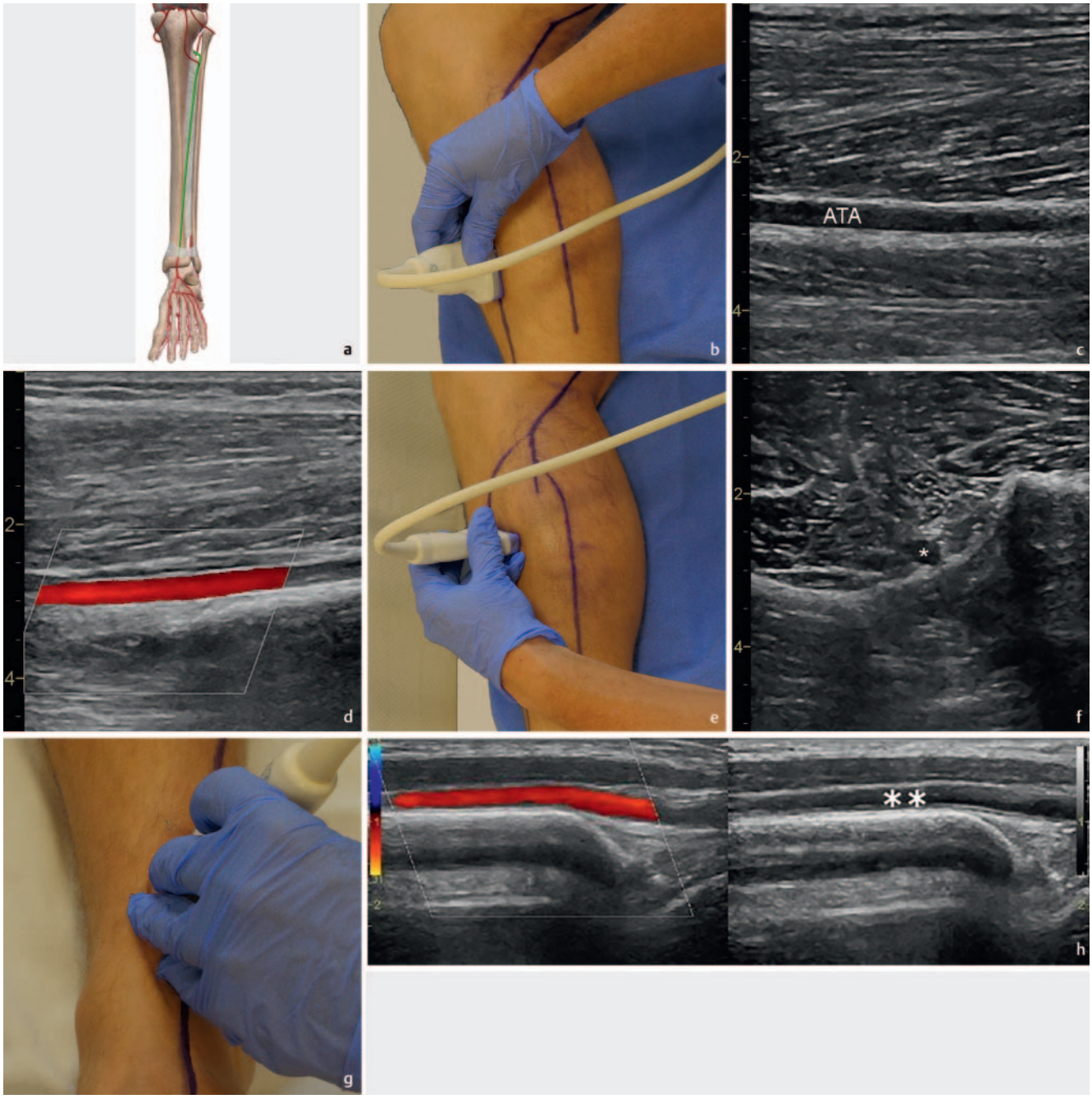
Arteries of the lower leg

PLEASE NOTE

All three arteries of the lower leg are usually accompanied by two veins that can be easily compressed.

Anterior tibial artery (Arteria tibialis anterior)

The anterior tibial artery arises from the popliteal artery at the distal edge of the popliteus muscle (▶ **Fig. 12**). It passes through the interosseus membrane into the anterior (extensor) compartment and supplies the anterior of the lower leg with numerous muscle branches.

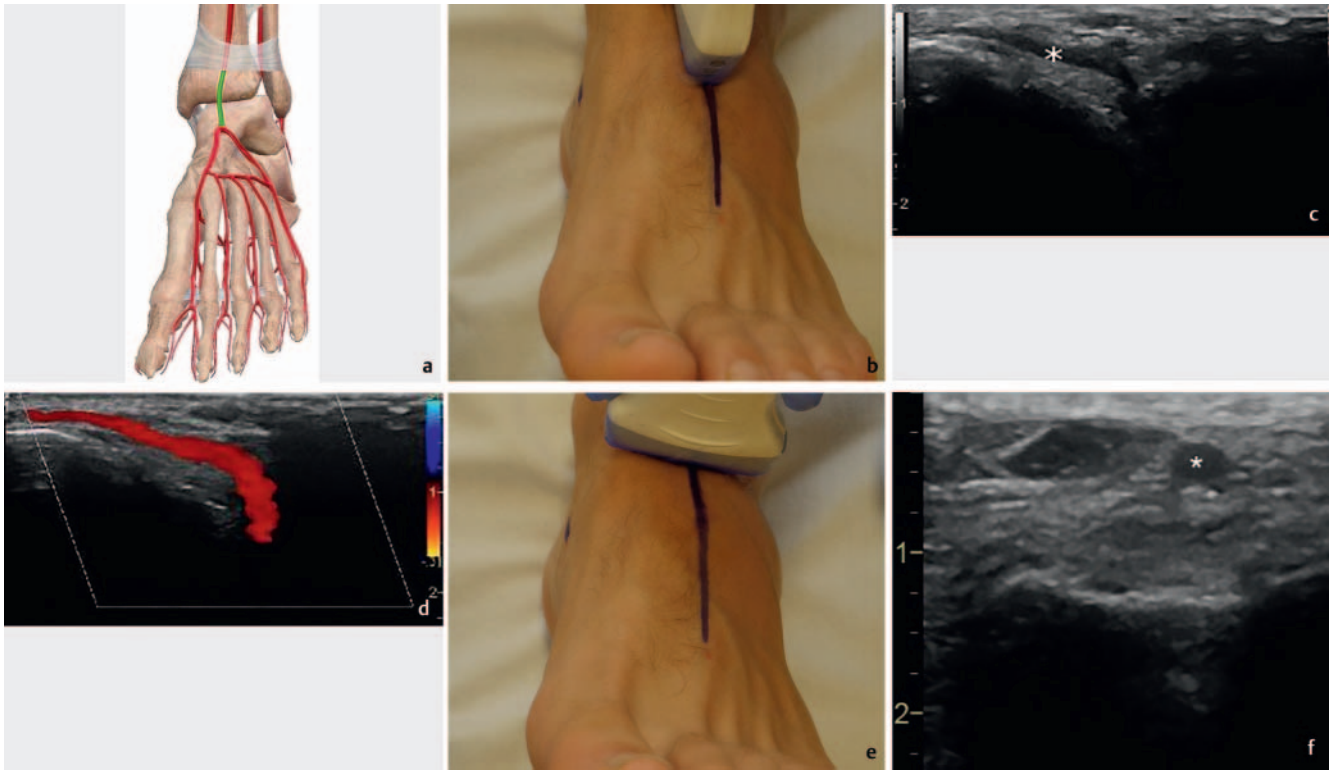


▶ **Fig. 13** Anterior tibial artery (*A. tibialis anterior*, ATA). **a** The anterior course of the vessel after it passes through the interosseous membrane is shown in green. **b** Position of the probe to examine the middle third of the anterior tibial artery in its longitudinal axis in the left leg with **c** the B-mode image thus obtained and **d** the colour-coded highlighted course of the vessel. **e** Rotation of the probe to give **f** the anterior tibial artery (*) seen in transverse section, running on the interosseous membrane. **g** Probe position shortly before the ATA becomes the dorsalis pedis artery, with (H, right) the colour-coded course of the vessel and (H, left) the B-mode image.

The division of the popliteal artery and the arrangement of its branches show multiple regional variations. Rarely, the popliteal artery divides at the distal edge of the popliteus muscle with a 'trifurcation' into the anterior and posterior tibial arteries and the fibular artery (peroneal artery). In other variants, the take-off of the anterior tibial artery lies above the popliteus muscle.

PLEASE NOTE

The most commonly used classification of the arterial anatomical variants in the lower leg describes nine different types [6]. The most common type, in which the anterior tibial artery is the first branch, accounts for about 90 %, while the other variants are found in the remaining 10 % of cases. In 80–85 % of cases, the same variant is present in both legs.



▶ **Fig. 14** Dorsalis pedis artery (*A. dorsalis pedis*, ADP). **aa** Anatomical course of the dorsalis pedis artery (green) on the dorsum of the foot before it divides into the deep plantar and first metatarsal arteries. **b** Finding the dorsalis pedis artery on the dorsum of the foot with the ultrasound probe to give **c** the B-mode image in longitudinal section showing the vessel running deeper into the tissues (*, left) with its course highlighted in colour on the right. **d** Corresponding position of the probe for **e** a transverse section of the dorsalis pedis artery (*) in a B-mode scan.

In the anterior compartment, the anterior tibial artery runs distally on the interosseus membrane together with its accompanying veins and the deep fibular nerve (also known as the deep peroneal nerve) enclosed by connective tissue in the anterior tibial canal, bordered medially by the tibialis anterior muscle and laterally by the extensor hallucis longus and extensor digitorum longus muscles. At the ankle, the vessels become more superficial and pass between the tibialis anterior and extensor hallucis longus tendons beneath the superior extensor retinaculum of the foot (transverse crural ligament) to reach the dorsum of the foot (▶ **Fig. 13**).

Below the inferior extensor retinaculum of the foot (cruciate crural ligament), the artery crosses beneath the tendons of the extensor hallucis longus and brevis muscles and runs laterally. As the dorsalis pedis artery on the dorsum of the foot, it is covered only by skin and subcutaneous tissue between the insertions of the extensor hallucis longus and extensor digitorum longus tendons in the first metatarsal space, where it branches into the deep plantar and first dorsal metatarsal arteries (▶ **Fig. 14**).

Like the other main blood vessels and nerves, the dorsalis pedis artery lies on the dorsum of the foot between the superficial and deep layers of the dorsalis pedis fascia. It usually gives rise to three branches: the lateral tarsal artery (*A. tarsalis lateralis*), the medial tarsal arteries (*Aa. tarsales mediales*) and the arcuate artery (*A. arcuata*). Perforating branches connect the dorsal metatarsal arteries (*Aa. metatarsalis dorsales*) arising from the arcuate artery to the arteries of the sole of the foot.

Posterior tibial artery (Arteria tibialis posterior)

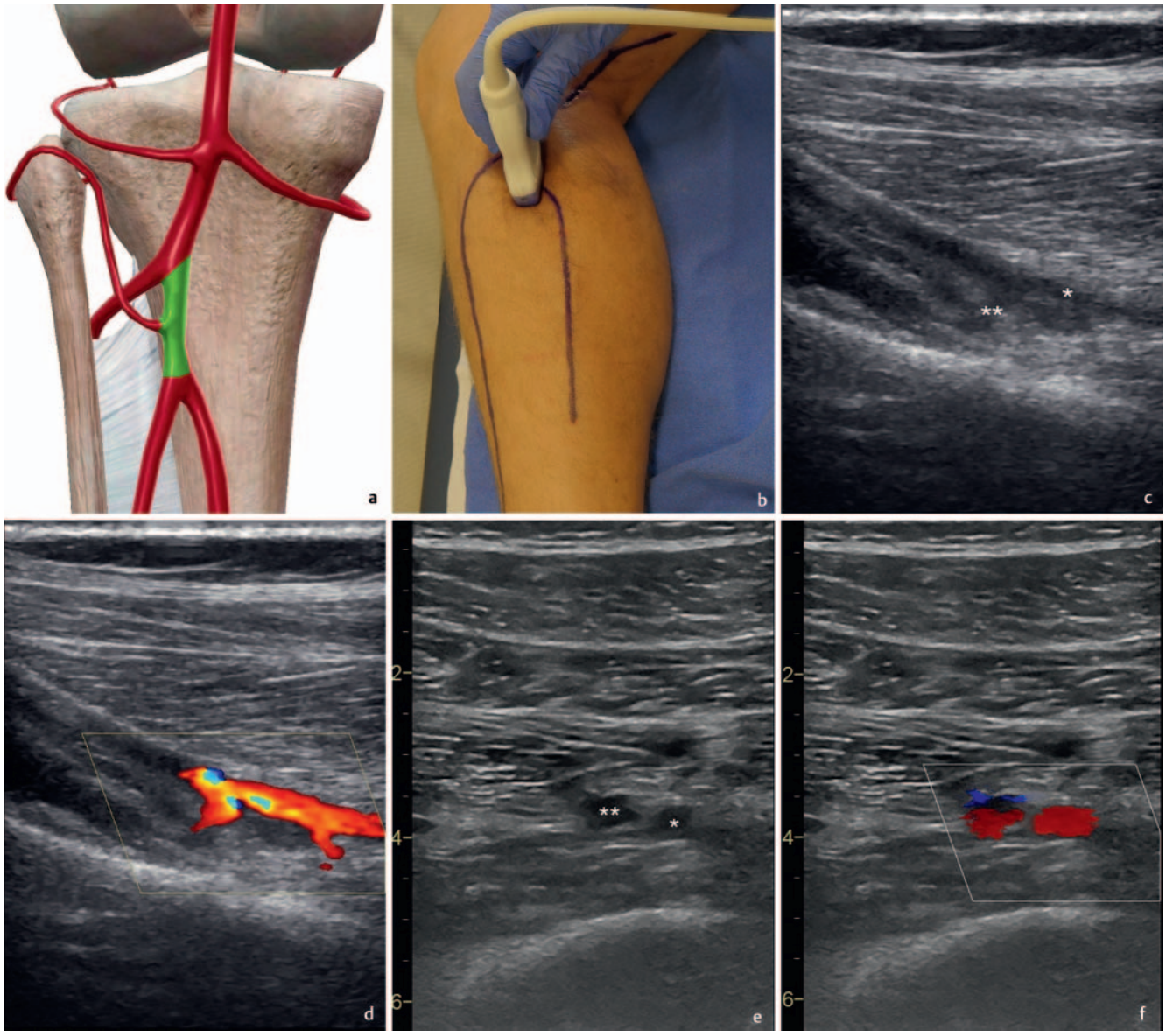
The posterior tibial artery is a terminal branch of the popliteal artery. The segment between the origin of the anterior tibial artery and the take-off of the fibular artery from the posterior tibial artery is referred to clinically as the tibiofibular tract (▶ **Fig. 15**).

The artery passes beneath the tendinous arch of soleus into the deep posterior (flexor) compartment (▶ **Fig. 15, 16**).

The posterior tibial artery supplies the deep flexor muscles as well as the tibia and its periosteum. In the ankle region, the posterior tibial artery becomes more superficial. It runs about 2 cm in front of the medial edge of the Achilles tendon, behind the medial malleolus, where its pulse can be felt (▶ **Fig. 17**).

Together with its accompanying veins and the tibial nerve, the posterior tibial artery passes around the medial malleolus. It then runs beneath the origin of the abductor hallucis muscle to the sole of the foot, where it divides into the medial and lateral plantar arteries. The medial plantar artery (*A. plantaris medialis*) is the weaker branch; it supplies the muscles in the medial compartment.

The lateral plantar artery (*A. plantaris lateralis*) runs to the lateral edge of the foot and supplies the muscles of the middle compartment and little toe. The artery forms the deep plantar arch (*arcus plantaris profundus*), from which four plantar metatarsal arteries (*Aa. metatarsales plantares*) arise. The arteries connect with the dorsal metatarsal arteries via the posterior and anterior perforating branches. The deep plantar arch and the deep plantar artery from the dorsalis pedis form a strong anastomosis. The digital arteries



▶ **Fig. 15** Tibiofibular tract (*tractus tibiofibularis*, TTF). **a** Anatomically speaking, the posterior tibial artery is the continuation of the popliteal artery. Clinically, the segment up to the take-off of the fibular artery is known as the tibiofibular tract (green). **b** The longitudinal position of the probe provides **c** a B-mode image showing the position of the tract (*) after the origin of the anterior tibial artery (**), which can be seen clearly in **d** the duplex scan. **e** Transverse section shows the outflowing anterior tibial artery (**) on the left and the tract (*) on the right, which is emphasised in **f** with colour-coding.

arise from the plantar metatarsal arteries, creating branches running on the plantar aspect of adjacent sides of the five toes as far as the distal phalanges, where they create a dense vascular network.

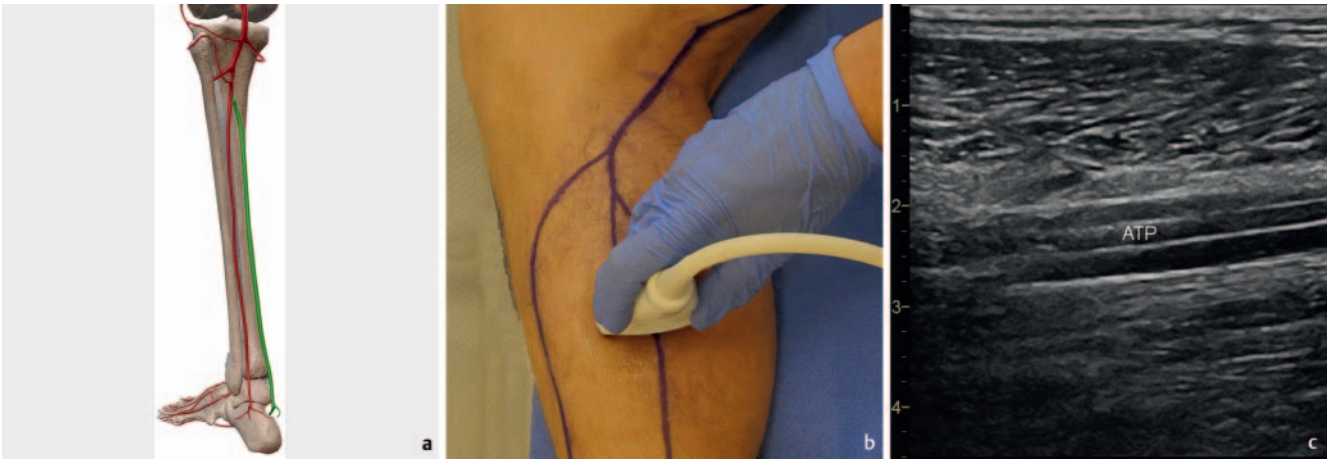
PLEASE NOTE

The posterior tibial and fibular groups can be clearly seen with a medial approach in the middle of the calf, directly on the anterior crest of the tibia (▶ **Fig. 17e**).

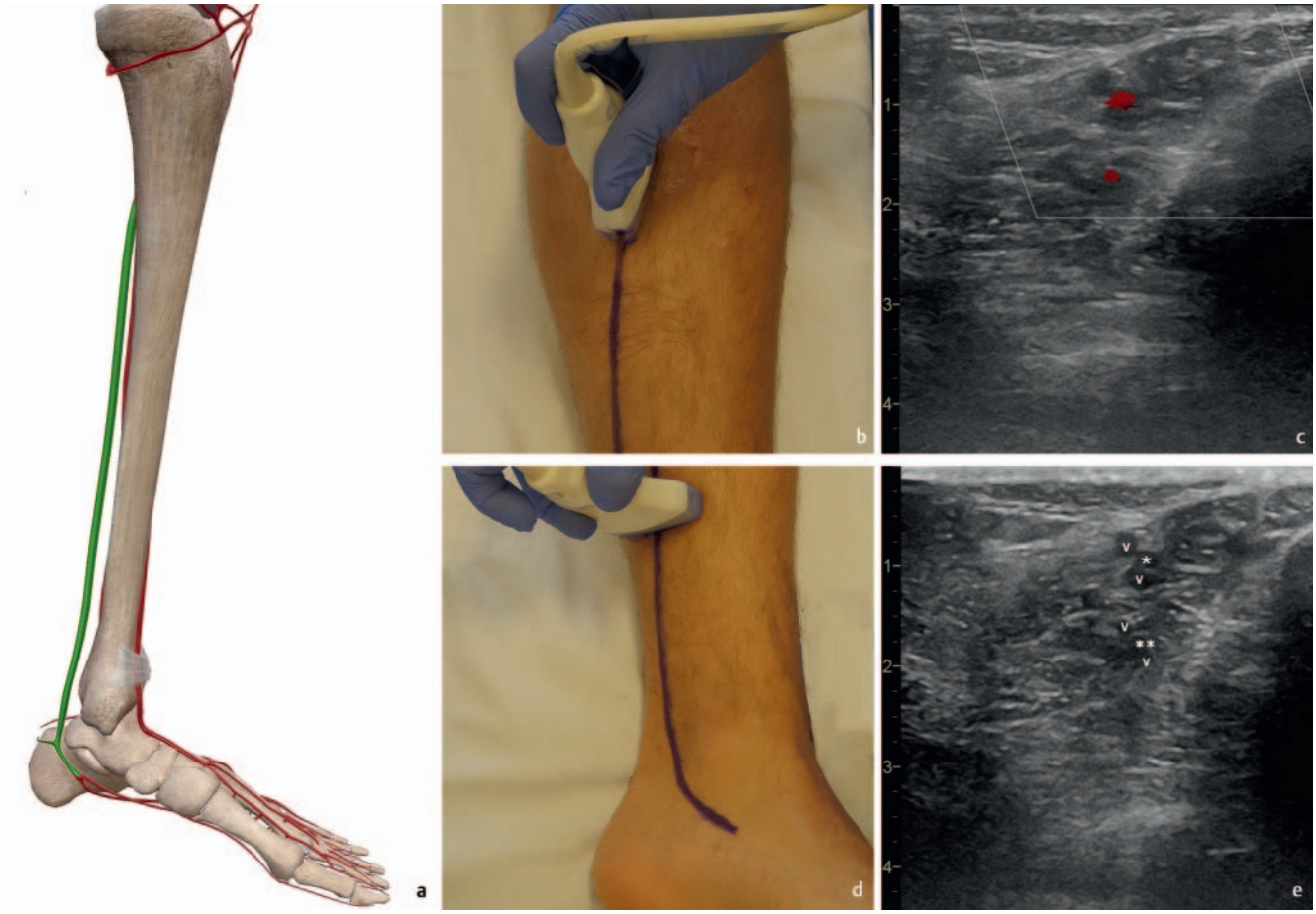
Fibular artery (Arteria fibularis; A. peronea)

The fibular artery, also known as the peroneal artery, is the strongest branch of the posterior tibial artery, arising at an acute angle a few centimetres below the popliteal fossa. It runs distally and laterally on the back of the fibula in the posterior calf, supplying the fibula and deep calf muscles (▶ **Fig. 18**). The fibular artery runs within the deep posterior (flexor) compartment and terminates behind the lateral malleolus (external ankle).

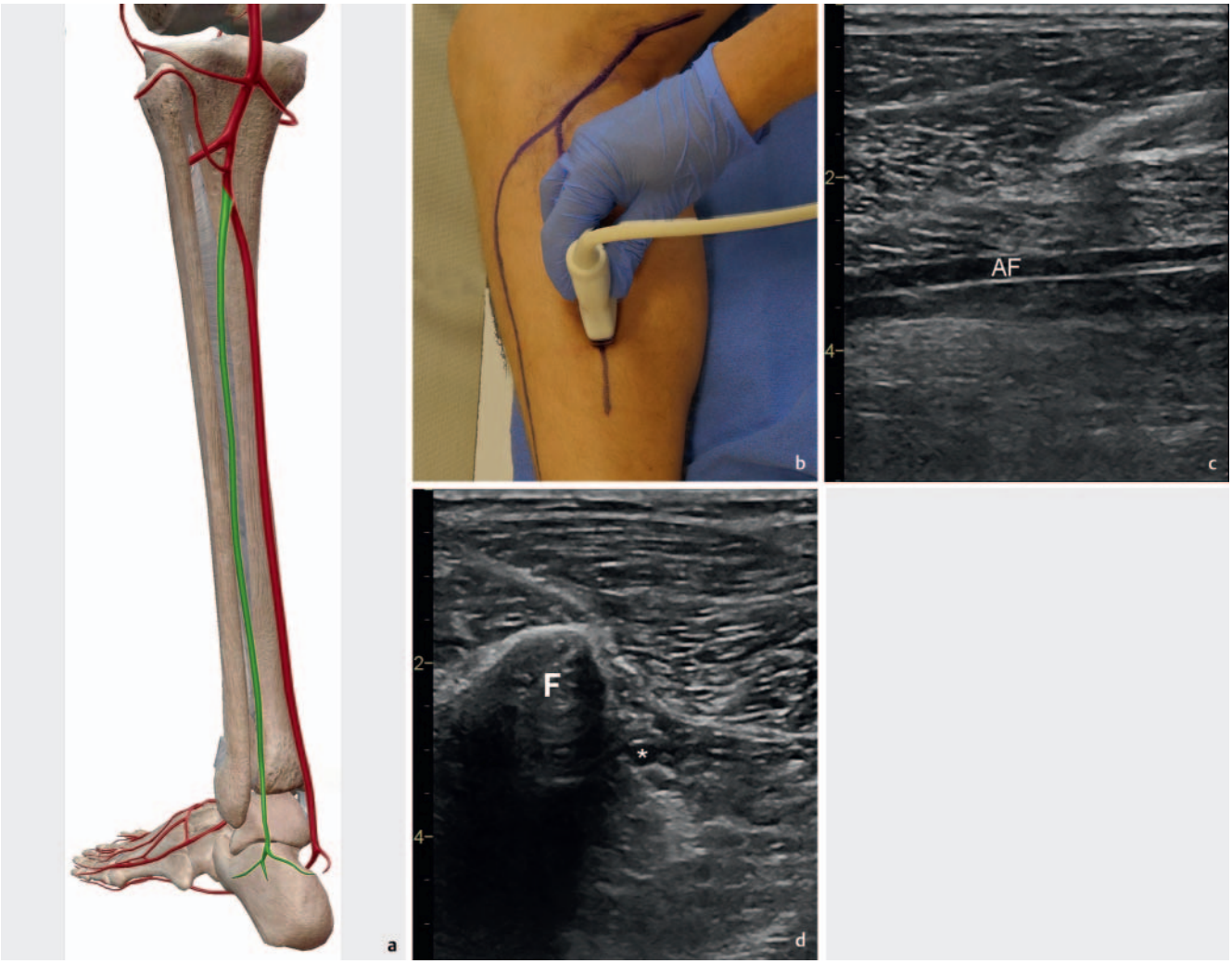
Along its course, the fibular artery gives off muscle branches that supply the muscles of the fibular group (peroneus longus and brevis) and the deep posterior compartment (soleus muscle



▶ **Fig. 16** Posterior tibial artery (*A. tibialis posterior*, ATP). **a** Anatomical course of the left posterior tibial artery (green) viewed from behind. **b** The proximal segment of the artery can be clearly seen in the right lateral position. **c** The B-mode image obtained shows the artery lying midway between the two accompanying veins (Vv. tibiales posteriores).



▶ **Fig. 17** Posterior tibial artery (*A. tibialis posterior*, ATP). **a** Course of the left posterior tibial artery (green) in the lower leg seen from a medial approach. **b** Position of the probe on the medial aspect of the leg with the patient lying supine for a longitudinal section through the middle third of the posterior tibial artery with **c** the corresponding B-mode image. **d** Rotating the probe transversely brings into view **e** the posterior tibial artery (*) as well as the fibular artery (**), each with its paired accompanying veins.



▶ **Fig. 18** Fibular artery (*A. fibularis*, AF). **a** Diagram of the anatomical course of the fibular artery (green) in the left lower leg, seen from behind. **b** A longitudinal position of the probe provides **c** a B-mode image of the artery; **d** in transverse section, it can be seen on the back of the fibula **F**.

and the deep flexors). Above the ankle, the fibular artery is connected to the posterior tibial artery via communicating branches.

If the anterior tibial artery or the posterior tibial artery is a weak vessel, the fibular artery may take over and supply their territory.

PLEASE NOTE

The fibular vessels can be demonstrated clearly from the medial and lateral aspects as well as from the posterior aspect. It is necessary to tilt the probe in order to find them.

A note on the ultrasonography

As a rule, the patient is examined in a supine position with the leg in slight external rotation at the hip. A 2–3.5 MHz sector (phased array) or vector transducer (probe) is used for the pelvic arteries as the expected penetration depth is some 15–20 cm. As the arteries below the groin lie superficially, a linear transducer with middle or high emission frequency (5–7.5 MHz) is used to obtain good morphological ultrasound signals. The arteries are demonstrated in the longitudinal and transverse planes. For longitudinal sections, the vessel is positioned in the B-mode image in such a way that the proximal segment of the vessel appears to the observer's left and the distal segment to the right. The popliteal artery may be examined with the patient supine or in a lateral position or less often with the patient lying prone.

The ultrasound images presented here were taken from healthy volunteers.

ABBREVIATIONS

ADP	Arteria dorsalis pedis = dorsalis pedis artery
AF	Arteria fibularis = fibular artery; peroneal artery
AFC	Arteria femoralis communis = common femoral artery
AFS	Arteria femoralis superficialis = superficial femoral artery

AIC	Arteria iliaca communis = common iliac artery
AIE	Arteria iliaca externa = external iliac artery
AII	Arteria iliaca interna = internal iliac artery
AP	Arteria poplitea = popliteal artery
APF	Arteria profunda femoris = deep femoral artery; profunda femoris
ATA	Arteria tibialis anterior = anterior tibial artery
ATP	Arteria tibialis posterior = posterior tibial artery
B-mode	Brightness modulation (standard two-dimensional grey scale ultrasound imaging)

Conflict of Interest

The authors declare that they have no conflict of interest.

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