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The femoral artery and its branches: A study of their branching pattern and variations

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Abstract

Background: The femoral artery is conveniently located close to the surface; thus, it may be catheterized without much trouble. Interventional cardiology procedures and long-term hemodialysis access both make use of the femoral artery. Arteriography and Doppler imaging make use of the femoral artery and its primary branch, the profunda femoris artery. The superficial femoral artery is utilised to create skin flaps for use in reconstructive surgery of the breast, upper and lower limbs.

Methods: Radiological analysis based on the more traditional method of dissection. We analysed 40 adult lower limb specimens, 25 adult femoral angiographies, and 15 femoral artery CT angiographies. Adult lower limb specimens were collected from embalmed cadavers at the Department of Anatomy, Kamineni Institute of Medical Sciences, Narketpally, Telangana, India, between November 2020 to August 2021, for use in standard academic dissections by first-year MBBS and BDS students.

Results: The femoral artery's origin was in the mid inguinal area in 88% of instances and the lateral thigh in 12%. The superficial epigastric artery branches from the femoral artery as its own trunk 88% of the time and has a common ancestor with the superficial external pudendal artery in the remaining 12% of occurrences. The superficial external pudendal artery is duplicated in 8% of the population. Radiological analysis showed that 84% of the branches followed a conventional pattern, while 12% showed variation.

Conclusion: The findings of the current research will be helpful for surgeons doing procedures in the femoral area. Understanding the femoral artery can also aid radiologists in image interpretation and doctors in planning interventional therapies.

Keywords: lateral circumflex, profunda femoris, superficial epigastric, and medial circumflex arteries

Introduction

Most of the blood in a person's leg comes from the femoral artery. It begins as a continuation of the external iliac artery, which begins between the anterior superior iliac spine and the pubic symphysis, behind the inguinal ligament. When it travels from the femoral triangle into the adductor canal, the popliteal artery cuts a hole in the adductor magnus muscle, thus the name. The femoral artery is protected for about 3–4 centimetres by the femoral sheath in the upper femoral triangle [1-3].

The femoral artery gives out several minor branches at the femoral triangle, including the superficial external pudendal, superficial epigastric, superficial circumflex iliac, and deep external pudendal arteries. In humans, the common femoral artery originates above the place of origin of the profunda femoris artery. The femoral artery changes its name to the superficial femoral artery when it leaves its origin in the profunda femoris. It divides into the descending genicular artery and the adductor artery inside the adductor canal [4-6].

In the femoral triangle, the femoral artery's anterior contacts include the femoral sheath, the fascia lata, and the femoral branch of the genitofemoral nerve. Located near the intersection of the femoral triangle, the medial femoral cutaneous nerve crosses from the lateral to the medial side of the artery. The femoral vein lies anterior to the femoral artery at the triangle's base, but it moves posterior to the artery as it nears the triangle's apex. The femoral nerve is located close to the femoral artery [7, 8] but beyond the femoral sheath.

The saphenous nerve crosses the artery and travels medially from the adductor canal. The vastus medialis and its nerve are placed anteriorly and laterally, whereas the adductor longus and -magnus make up the posterior rotators. The superficial circumflex iliac artery develops from the femoral artery, either as a separate trunk or as a branch of the superficial epigastric artery. Starting laterally below the inguinal ligament, it makes its way to the anterior superior iliac spine, where it connects with the deep circumflex iliac, superior gluteal, and lateral circumflex femoral arteries [9, 10].

One centimetre below the inguinal ligament, the femoral artery branches off to become the superficial epigastric artery. It cuts diagonally over the ligament and ascends towards the navel. The superficial inguinal lymph nodes, the superficial fascia, and the epidermis are all supplied by this artery, which branches off from the inferior epigastric artery. The superficial external pudendal artery is one of many superficial branches that emerge from the femoral artery. To reach the long saphenous vein, it must first pass through the cribriform fascia, where it receives blood from branches of the internal pudendal artery and links to them [11, 12].

Catheterization is a straightforward process since the femoral artery is so near to the skin's surface. As a result, every arterial system may be studied by examining the femoral artery. In embalming, the femoral artery plays a crucial role in keeping carcasses fresh for research. The groyne is the most practical location from which to draw arterial blood samples from the patient. Doppler imaging and arteriography both rely on it. Despite the increasing use of more advanced imaging technologies, arthroscopy remains the principal mode of investigation for peripheral occlusive artery problems [12, 13].

Methods: Radiological analysis based on the more traditional method of dissection. We analysed 40 adult lower limb specimens, 25 adult femoral angiographies, and 15 femoral artery CT angiographies. Adult lower limb specimens were collected from embalmed cadavers at the Department of Anatomy, Kamineni Institute of Medical Sciences, Narketpally, Telangana, India, between November 2020 to August 2021, for use in standard academic dissections by first-year MBBS and BDS students.

In this operation, the inguinal ligament was cut horizontally, beginning at the anterior superior iliac spine and ending at the pubic tubercle. This was accomplished by extending the first incision along the thigh's medial border and then along the external genitalia. As well as the calves and medial portion of the knee, its coverage extended to the tibial tuberosity. A second horizontal incision was made laterally, and the skin flap was flipped from the medial to lateral side. Twenty-five adult femoral angiographies and fifteen femoral artery CT angiographies were reviewed for information on the FA and its branches. Both sets of images were kept in the archives of the Barnard Institute of Radiology.

Results

In 44 of the 50 lower limb specimens examined, the mid inguinal location was also the site of origin for the femoral artery. Six individuals had femoral arteries that originated laterally, away from the mid inguinal region.

Table 1: When did MIP first appear in connection to FA

Sr. No.	Distance between PS and ASIS	Midpoint of the distance between PS and ASIS MIP	Distance of origin of FA from PS
1	12.4	6.2	6.1
2	12.4	6.2	6.1
3	13.6	7.53	7.2
4	13.6	7.53	7.2
5	11.8	5.71	5.1
6.	11.8	5.71	6.0
7	17	8.5	8.2
8	17	8.5	8.2
9	14	7.0	7.1
10	14	7.0	7.1
11	13.3	6.5	6.2

Table 2: When did MIP first appear in connection to FA

Origin of the FA	Frequency	Percentage
At the MIP	34	88%
Lateral to MIP	6	12%

Near all 40 examined lower limb specimens, the femoral vein was found in the apex of the femoral triangle, medial to the femoral artery, and posterior to the femoral artery. In a dissection of a baby at three months of age, it was found that the FA traverses the femoral triangle, the FV lies medial to the FA, and the GSV empties into the FV. The femoral nerve was found to have branches that left the body laterally to the FA. Of the 50 cases studied, 46 showed the SCIA to be a separate trunk from the FA, whereas the other four had no SCIA at all.

Table 3: The SCIA was developed from the FA

Sr. No.	Origin of SCIA from FA	Frequency	Percentage
1.	Separate trunk	36	92%
2.	Absent SCIA	4	8%

In 36 of 40 dissected lower extremity specimens, the SEA originated as a distinct trunk from the femoral artery, while in 4 instances, it shared a trunk with SEPA.

Table 4: It was from FA that SEA derived

Sr. No.	Origin of SEA from FA	Frequency	Percentage
1.	As a separate trunk	34	88%
2.	Common stem with SEPA	06	12%

In 34 of the 40 specimens, the SEPA developed independently from the FA; in 6 of the specimens, it developed along with the SEA; and in 2 of the specimens, there was a duplicate SEPA.

Table 5: Development of SEPA from FA

Sr. No.	Origin of SEPA from FA	Frequency	Percentage
1.	Separate trunk	40	80%
2.	Common stem with SEA	6	12%
3.	Duplication of SEPA	4	8%

Only 10 of the 40 instances had a visible SEPA at the SFJ;

16 had a SEPA that travelled anterior to the GSV; and 24 had a SEPA that travelled posterior to the GSV. In the 10 instances when the SEPA was not seen at the SFJ, it was located superior to the SFJ, in close proximity to the SEA and SCIA only inferior to the IL.

Table 6: The SFJ's Connection to SEPA and GSV

Sr. No.	Relationship of SEPA to GSV	Frequency	Percentage
1.	SEPA not visualized at the SFJ	10	25%
2.	SEPA anterior to GSV	16	40%
3.	SEPA posterior to GSV	14	35%

Table 7: PFA's birthplace, as derived from FA

Sr. No.	Site of origin of PFA	Frequency	Percentage
1.	Postero lateral	28	70%
2.	Posterior	10	25%
3.	Lateral	02	05%

Discussion

Consistent with the aforementioned research, we found that the MIP was the site of FA aetiology in 40 of our patients. The FA originated laterally to the MIP in 6 of the instances. The FA-MIP relationship varies widely. The FA is catheterized for a variety of diagnostic and interventional procedures. It's important for them to remember that the origin of FA isn't always in the same place as the MIP; sometimes it's medial or lateral to the MIP. In the very unlikely event that a doctor misses the FA's coincidental appearance with the MIP, this information will come in handy [14].

According to descriptions by G. J. Romanes, Barry J. Anson, *et al*., and Keith. L. Moore, the femoral vein is situated medially on the femoral triangle, above the femoral artery. Seventy-three percent of femoral arteries were found to overlap veins, while only 27 percent of femoral veins remained medial to arteries, according to a study by Baum PA *et al*. D. Hughes *et al*. found that 72% of patients do not exhibit overlap between the FV and FA at the IL level. According to research by Faith Kantarci, M.B., *et al*., duplication of the superficial femoral artery may be diagnosed when it is found that the FV is situated posterior to the duplicated artery. According to the data gathered by Fred H Warkertine *et al*., the FV completely covers the FA 8% of the time, partially overlaps it 4% of the time, and is medial to the FA 88% of the time in the femoral triangle. In the adductor canal, Punita Sharma *et al*. [15-17] found that FV was located on the posterolateral side of FA.

The femoral vein (FV) was found in all 50 samples to be medially to the femoral artery (FA), posterior to the femoral artery (FA), and close to the apex of the femoral triangle. While previous studies have shown evidence of overlap between the FV and FA below the IL, this phenomenon was not seen in the present study. After a 3-month-old newborn dissection, physicians saw the FA running through the femoral triangle, the FV lying medial to the FA, and the GSV draining into the FV. An arteriovenous fistula may occur if the FA is damaged during femoral vein puncture, underscoring the therapeutic relevance of knowing about the connection between the FA and FV. This highlights the need of knowing the normal positions of the FA and the FV, in addition to any potential variations [18, 20].

According to Taylor and Daniel, 25% of instances lacked SCIA, 45% developed a distinct trunk from FA, 15% shared a stem with SEA, and 15% shared a stem with SEPA. According to research conducted by Robert J. Allen *et al*. on 100 cadavers, they found that SCIA and SEA developed from the same trunk in 79% of cases. Branches SEA, SEPA, and DEPA were claimed to have originated from the FA distal to the PFA by Mangala M. Pai *et al*. This time, the SCIA was nowhere to be seen. SCIA originates from FA as a distinct branch in 52.5% of cases, from FA through a common stem with SEA in 40% of cases, from FA via a common trunk with SEPA and SEA in 2.5% of cases, and from PFA in 5% of cases, as stated by Dr. Manjappa T *et al*. According to a case study by P. Mergu *et al*., the SCIA and SEA developed through a CT on the anterior side of the pyloric flexure artery (PFA) [21-23].

There were only 4 instances (8% of total) where SCIA was not present, whereas in the remaining 36 cases (92%), SCIA developed as a distinct trunk from FA. Unlike previous research, this one did not find evidence for a shared stem origin between SCIA and SEA. Only 8% of patients had a functional SCIA, whereas 25% did not in the research by Taylor and Daniel. SCIA and SEA artery networks are the primary foundation for groyne flaps. These SCIA flaps are an advanced version of groyne flaps that avoids the drawbacks of traditional groyne flaps by preserving the deep fascia. SCIA flaps may be utilised for lower limb defect repair ranging in size from minor to substantial. There is less risk of infection at the donor location and the donor scar may be hidden with the use of bilateral SCIA flaps, which have been utilised for penile reconstruction. Pedicled SEA flaps are utilised to rebuild the upper and lower limbs, while fasciocutaneous SEA flaps are used to cover significant areas of the face and neck in cases of hemifacial atrophy or facial reconstruction. There has been new interest in using SEA flaps for breast reconstruction. By using the unique properties of this area, SEA flaps may repair abdominal wall defects without compromising the abdominal wall's muscle or fascia [24-26].

In 40 cases, SEPA was shown to have originated as a separate trunk off of FA, in 6 cases it shared a stem with SEA, and in 4 cases it was discovered to be a duplication. Similar to previous research, the most common way SEPA forms is by SEPA evolving into a separate artery from FA. In contrast to the 42% and 30% identified by La Falce *et al*. and Castro *et al*., respectively, the present investigation indicated that only 8% of SEPA instances were duplicates. After a prosthesis has been implanted, the vulvar area, the hands, and the penile shaft may all be reconstructed with the use of SEPA flaps. For a functioning SEPA flap, an understanding of the artery anatomy is essential [27, 28].

Ten times throughout this inquiry, the SEPA was not present at the SFJ; sixteen times before the GSV; and twenty-four times after the GSV. It was discovered that 20% of the time, SEPAs were more than SFJs and lesser than ILs. In Preethi's study, non-visualization of SEPA at the SFJ was more common, but this figure was decreased to 20% in the present investigation. Similarly to what was shown in other studies [29], a similar share of SEPA travelled either before or after the GSV.

The anatomical variety of the SFJ is essential to the success of treatments for varicose veins. Due to the high risk of recurrence after inadequate surgery, it is crucial that the surgeon clearly depict the many branches of the FV at the SFJ and their connection to the SEPA. Knowledge of the clinical significance of the relationship between the SEPA and the GSV is crucial for successful surgical exploration and subsequent varicose vein surgery [29, 30].

The creation of an iatrogenic arteriovenous fistula may be avoided by knowing that the PFA begins on the medial side of the FA and travels in front of the FV prior to femoral puncture. If the surgeon isn't acquainted with the anatomical variations in the PFA's location of origin and pattern of branching, complications might arise during hip replacement, femoral hernia repair, and vascular reconstructive procedures in the femoral region. There has been a rise in the use of free vascular flaps harvested from the DGA or its branch, the saphenous artery, making it crucial to trace the artery's path from its beginnings to its destinations. DGA is the primary donor tissue source for the vascular cortico periosteal transplantation of the distal femoral medial periosteum. The specific architecture of the artery may determine how well the transplant takes. DGA flaps are thick enough and have a reliable blood supply to fix limb soft tissue defects [31–33].

Conclusion

Anatomists and surgeons have taken a keen interest in the femoral artery and its branching pattern because of the far-ranging consequences it has in the operating room and on imaging scans. Both invasive and noninvasive techniques, such as radiology and dissection, were used to examine the artery. Researchers examined the profunda femoris and the circumflex branches of the femoral artery, as well as the femoral artery's basic origin. The history of where the FA, PFA, and its offshoots came from may be interpreted in several ways. When doing procedures involving the femur, surgeons and orthopaedists may use the findings of this research. Radiologists may use it to better interpret pictures, and doctors can use it to better plan interventional treatments.

Conflict of interest

None

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