

Popliteal artery branching pattern: a cadaveric study

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SUMMARY

The study on 30 embalmed human cadavers (60 lower limbs) was carried out to find out the variations in the branching pattern of the popliteal artery. Sixty embalmed lower limbs (30 left, 30 right) belonging to 30 adult human cadavers (54 males, 6 females) formed the material for this study. The approximate age of the cadavers was 25-60 years. Variations related to the origin and disposition of the collateral branches of the popliteal artery were observed in 9 (15%) limbs as follows: common trunk between superior lateral genicular and middle genicular artery in 7 (5 male, 2 female) specimens; double middle genicular arteries in 1 male specimen; and inferior lateral genicular artery was arising from anterior tibial artery in 1 male specimen. Variations related to termination of the popliteal artery are depicted as follows: in 2 male specimens, left side unilateral variation of the high division of the popliteal artery was observed. The bifurcation of the popliteal artery at the level of the proximal border of the popliteus muscle was observed, the prevalence being of 3.3%. Out of these 2 limbs, in one of them variation of the origin of the peroneal artery from the anterior tibial artery was observed. Variations of popliteal artery were

observed in 15% of specimens. Knowledge of these variations will be beneficial to angiographers for the evaluation of arteriograms, and to vascular surgeons for various surgical approaches in the lower extremity.

Key words: High division – Tibial arteries – Peroneal artery – Popliteus muscle

INTRODUCTION

The popliteal artery is a common receiving site for above- or below-knee bypass grafts. It is also frequently affected by penetrating and blunt trauma involving the lower extremity. Exposure of this artery is therefore, often required in both emergent and elective vascular procedures (Colborn et al., 1994). Knowledge of the anatomic variability in this region may have clinical implications regarding vascular grafting, direct surgical repair, transluminal angioplasty, embolectomy, or the diagnosis of arterial injury (Mauro et al., 1988). Knowledge of the anatomical variations in the branching of the popliteal artery is important because damage to its branches can be limb- or life threatening (Tindall et al., 2006).

The popliteal artery is the continuation of the femoral artery. From the opening in adductor magnus it descends laterally to the intercondylar fossa, inclining obliquely to the distal border of the popliteus.

The popliteal artery gives off several collateral branches: 1, the cutaneous branches; 2, the muscular branches and 3, the genicular branches. The genicular branches are: 1, the medial superior; 2, the lateral superior; 3, the middle, which pierces the oblique popliteal ligament to supply the cruciate ligaments and synovial membrane; 4, the lateral inferior, and 5, the medial inferior genicular arteries. All the genicular branches from the popliteal artery are anastomosed among one another, and also with the contribution of the descending genicular artery, originated from the femoral artery. All of them make up the arterial network of the knee.

The popliteal artery divides into the anterior and posterior tibial arteries at the level of the superior merge of the interosseous membrane. The peroneal artery arises from the posterior tibial artery, 2.5cm distal to the popliteus muscle, and passes obliquely to the fibula, descending along its medial crest, either in a fibrous canal between tibialis posterior and flexor hallucis longus, or within flexor hallucis longus (Williams and Newell, 2005a, b).

According to Adachi (1928), any terminal division of the popliteal artery which takes place at a level above the middle of the posterior surface of the popliteus muscle must be considered as a "high division". He reported high division in 2.8% specimens.

A true trifurcation of the popliteal artery is unusual, occurring in 0.4% of instances, although variations of a splitting of the popliteal into three branches in close proximity are more common, occurring in about 3% of specimens (Lippert and Pabst, 1985; Mauro et al., 1988).

Agensis of the popliteal artery, although obviously extremely rare, has been reported (Senior, 1919). In this case, the anterior tibial and the peroneal arteries originated distally from multiple collateral channels.

MATERIAL AND METHODS

Sixty embalmed lower limbs (30 left, 30 right) belonging to 30 human cadavers from the Department of Anatomy, Government

Medical College, Patiala, comprised the material for this study. Out of a total of 60 limbs, 54 belonged to males and 6 to females. The approximate age of the cadavers was 25-60 years. No clinical histories of the studied specimens were available. No knee or vascular surgery was performed in the study group. The cadavers were dissected according to Cunningham's manual of practical anatomy (Romanes, 2003). The popliteal artery was exposed in the popliteal fossa and the prevailing pattern of the popliteal artery, its branches and variations were observed, noted and photographed. The data were compiled, and the observations were compared with previous standard observations.

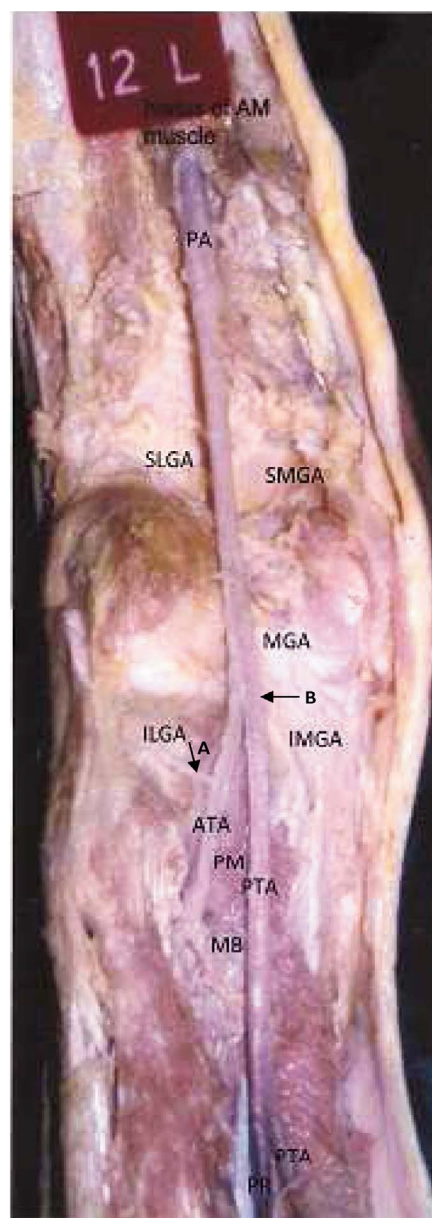


Fig. 1. Posterior view of left popliteal artery (PA) depicting (A) inferior lateral genicular artery (ILGA) arising from high anterior tibial artery (ATA); (B) high division of popliteal artery (PA); PM = popliteus muscle; PTA = Posterior tibial artery.

RESULTS

Variations related to origin and disposition of the collateral branches of the popliteal artery were observed in 9 (15%, 7 male, 2 female) specimens as follows:

1. Common trunk for superior lateral genicular and middle genicular artery (Fig.3).
2. Double middle genicular arteries (Fig. 2).
3. Inferior lateral genicular artery arising from high anterior tibial artery (Fig.1). Variations related to termination of the popliteal artery are depicted as follows:

1) In 2 male specimens, unilateral variation of high division of the popliteal artery was

observed, prevalence being of 3.3%. The bifurcation of the popliteal artery at the level of the proximal border of the popliteus muscle was observed (Figs.1 & 2).

2) In the present study, both limbs of the high division of the popliteal artery bifurcated into anterior and posterior tibial arteries. These arising anterior and posterior tibial arteries were running on the posterior surface of the popliteus muscle (Fig.1 and 2).

3) Out of these 2 limbs, in one of them variation of origin of the peroneal artery from the anterior tibial artery was observed (Fig.2).

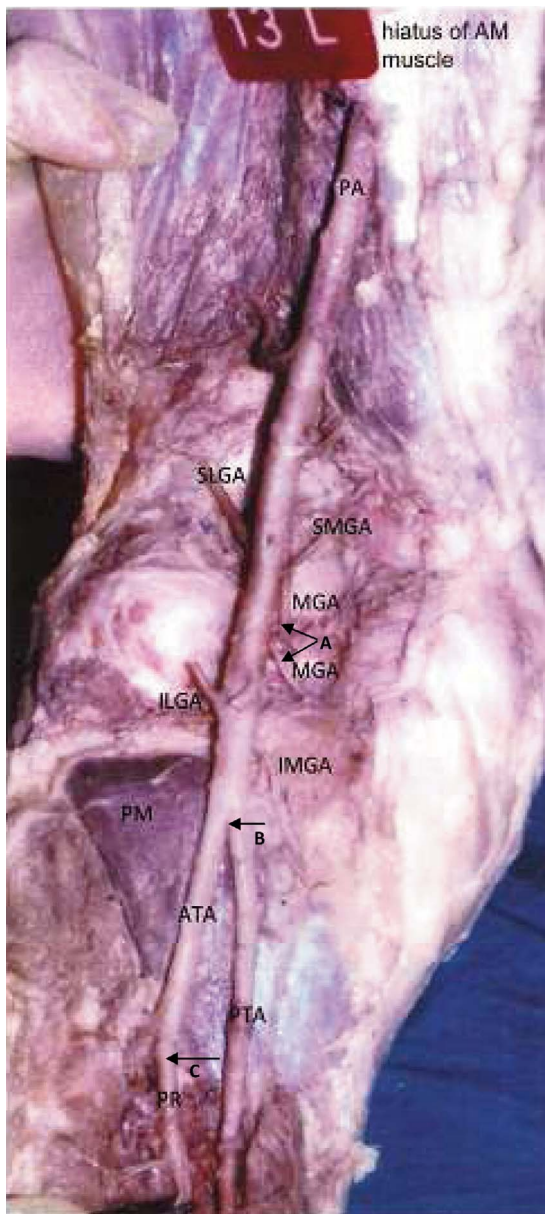


Fig. 2. Posterior view of left popliteal artery depicting (A) double middle genicular arteries (MGA) ; (B) high division of popliteal artery (PA) ; (C) peroneal artery (PR) arising from anterior tibial artery (ATA); PM= popliteus muscle; PTA=posterior tibial artery.

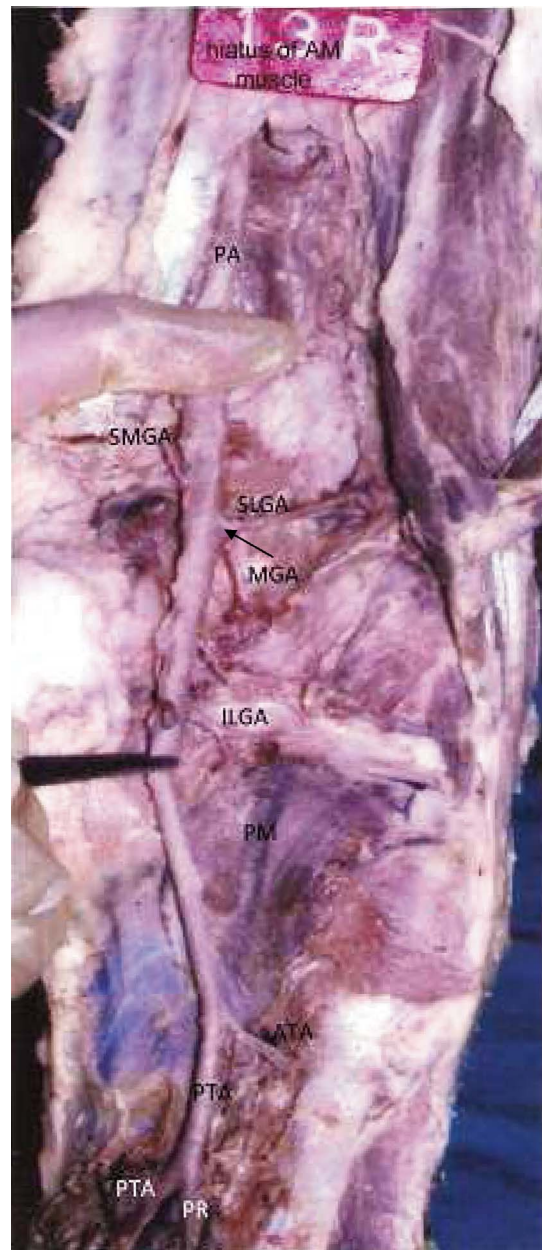


Fig. 3. Posterior view of right popliteal artery depicting common trunk for superior lateral genicular artery (SLGA) and middle genicular artery (MGA)

DISCUSSION

The morphological fluctuations of organs or a part of the body, which do not mean a functional "handicap" for the individual, may be considered as an "anatomical variation" (Lippert and Pabst, 1985). Variations of the arterial patterns or so-called "abnormalities" have received considerable attention in the anatomical literature. An "abnormality" does not in any way imply an inferior or less effective blood supply of the region, but is simply a variation or departure from the "normal" (Keen, 1961). In the present study, variations in origin and disposition of the collateral branches of the popliteal artery were observed as a common trunk for superior lateral genicular and middle genicular artery in 7 (3L, 3R, 4R, 5R, 8R, 12R, 13R) specimens. The distance of origin of the common trunk was measured from the knee joint line, which was represented by a line drawn around the limb at the level of the upper margins of the tibial condyles (Halim, 1993).

The common trunk originated from popliteal artery 2 to 4 cm proximal to the joint line. Similar findings have been observed by Salaria and Atkinson (2008) during the dissection of 8 cadavers (4 males and 4 females). They reported the origin of the middle genicular artery 3-5 cm proximal to the joint line, either alone or having a common origin with the superior lateral genicular artery.

Double middle genicular arteries were observed in one specimen (13L) of which one middle genicular artery shared a common trunk with the superior lateral genicular artery and another arose from the popliteal artery. The findings in the present study are in agreement those of a study performed by Scapinelli (1997). He reported that the middle genicular artery may show variations in its origin and is frequently double. The inferior lateral genicular artery arose from the anterior tibial artery in 12L, a case not yet reported in the accessible published literature.

In general, these anomalous patterns may present differences in the mode and the proximo-distal level of branching: the presence of unusual compound arterial segment or aberrant vessels that connect with other principal vessels, like arcades or plexuses (Collins, 2005). Thus, embryonic vessels may either persist or degenerate (degeneration of these

vessels is normal), or abnormal fusions may occur (Arey, 1974).

Variations in the branching of the popliteal artery revolve around the high division of that trunk and the resulting differences in the arrangement of the terminal branches, posterior tibial, anterior tibial and peroneal arteries (Keen, 1961). A comparison of the high division of popliteal artery, the origin of the peroneal artery and the relationship of the anterior tibial artery with the popliteus muscle in the high division of the popliteal artery observed in the present study with previous cadaveric studies is shown in Tables 1 and 2.

A high division of the popliteal artery was observed in 3.3% of cases which is more or less in consonance with Adachi observations, which report Asian data (Japanese), whereas percentages are considerably higher in American and European data. The possibility that these results may depend on racial or regional differences cannot be ruled out, and will need further study, with greater number of cases involving different races and regions.

An embryological study by Senior (1929) provided a clear explanation of the way in which high division of the popliteal artery can arise. In the embryo before the 14 mm stage the axis artery of the lower limb is the *arteria ischiadica*. At the knee-joint level the axis artery becomes the popliteal, which at this stage runs in front of the popliteus (deep popliteal artery), and then continues as the anterior tibial. At the 14 mm stage, the *arteria ischiadica* is being supplemented by the femoral artery. Two longitudinal arteries which traverse the leg in the embryo, the future posterior tibial and peroneal arteries, arise from the axial vessel at the upper border of the popliteus muscles. A gradual proximo-distal union of the posterior tibial and peroneal arteries occurs and is well advanced in embryos of 20 mm. This union forms the part of the definitive popliteal artery that lies behind the popliteus muscle. A communicating branch from the lower border of the popliteus enlarges to become the definitive anterior tibial, while the deep popliteal artery gradually disappears.

In most cases, the peroneal artery arises from the posterior tibial artery about 2.7cm below the level of bifurcation at the lower border of the popliteus (Keen, 1961). However, it can be easily understood that, if the proximo-distal fusion of the posterior tibial and per-

Table 1. High division of popliteal artery -present study compared to previous studies.

Authors/ Year	No. of specimens studied	High division of popliteal artery
Parson & Robinson (1898)	106	8.2%
Adachi (1928)	770	2.8%
Trotter (1940)	264 (American whites)	4.9% 338 (Negroes) 6.2%
Keen (1961)	280	5%(14)
Colborn et al (1994)	42	7%(3)
Present study (2008)	60	3.3%(2)

Table 2. Origin of peroneal artery and relation of anterior tibial artery to popliteus muscle in high division of popliteal artery-present study compared to previous studies.

Authors/ Year	No. of specimens studied	Origin of Peroneal artery from anterior tibial artery	Anterior tibial artery coursed superficial to popliteus muscle	Anterior tibial artery coursed deep to popliteus muscle
Parson & Robinson (1898)	106	-	6	2
Keen (1961)	280	3	13	1
Colborn et al (1994)	42	3	2	1
Present study (2008)	60	1	2	-

oneal vessels is abbreviated, the peroneal artery can consequently arise from the anterior tibial rather than from the posterior tibial (Neville et al., 1990).

Another variation of the popliteal artery is trifurcation, where all three terminal branches arise together at the level of the lower border of the popliteus muscle. Trifurcation of the popliteal artery into anterior, and posterior tibial and peroneal branches was observed in 0.8% specimens (Adachi, 1928). Trifurcation was reported 12 times (4.3%) in Keen's study (1961), but it was not observed in the present study.

Thane (1892) cited a case in which the popliteal artery extended to the middle of the back of the leg before dividing. He also reported an instance in which the popliteal artery divided into two branches which reunited after a course of 5 cm. Absence of the peroneal artery has also been recorded by him, but such a case was not encountered by the present researchers.

Lippert and Pabst (1985) reported a case in which a vessel directly connected the popliteal artery at the level of the knee joint to the proximal portion of the tibioperoneal trunk, forming what they have called an 'island'. This rare anomaly was thought to represent a persistence with abnormal fusion of the popliteal artery. According to Broman (1921), the arteries of the upper limb are formed at the end of the second month, and they have a pattern that corresponds to that of the adult. In the case of the lower limb, the adult pattern is completed somewhat later, during the third

month. Therefore, the factors that produce departures from the so-called "normal" patterns must be active at the embryonic stage. In view of the early developmental establishment of the adult patterns, it is probable that all arterial variations are of genetic origin, and it has been shown that these genetic factors act more often in an independent manner in the right and left limbs, and less often bilaterally (Keen, 1961).

In conclusion, variations of the popliteal artery were observed in 15% specimens. It is not rare to find variations of the popliteal artery in the popliteal fossa. The literature is replete with data of variations of the popliteal artery and its branches, but the reason for the presence of such variations lies in their embryological development. Understanding the development of different tissues may answer most of our queries in relation to variations in anatomical structures. Awareness of these variations will be beneficial to angiographers for the evaluation of arteriograms, and to vascular surgeons for various surgical approaches, as well as for the choice of suitable arterial graft sites.

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