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Research Article

A study of variations in the branching pattern of popliteal artery and its clinical perspective

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ABSTRACT

Background: Popliteal artery is the continuation of femoral artery which is the main and prime arterial supply to the knee, leg and foot. Variations of popliteal artery have been the subject of repeated study as exposure of this artery is required in both emergency and elective vascular procedures. Knowledge of the anatomical variations in the branching of popliteal artery is important, because damage to artery and its branches can lead to limb disability or life threatening haemorrhage.
Methods: A total of 40 popliteal arteries were studied by dissection method. Specimens were collected from the cadavers which were available in the department of anatomy, JSS medical college, Mysore, India.
Results: The origin, course and termination of the popliteal artery in all the 40 specimens were normal. Regarding the branching pattern of genicular arteries, there was a common stem of origin for superior medial genicular artery (SMGA), middle genicular artery (MGA), superior lateral genicular artery (SLGA) in 2 specimens (5%).
Conclusions: Popliteal artery is the commonly approached site for above and below knee bypass grafts. It is also frequently injured during penetrating and blunt trauma involving lower extremity. Although prevalence of the variations was less in our study, the awareness of possible variations will be beneficial to angiographers and to vascular surgeons and orthopaedic surgeons.

Keywords: Popliteal artery, Superior medial genicular artery, Middle genicular artery, Superior lateral genicular artery

INTRODUCTION

Popliteal artery is the continuation of femoral artery, which extends obliquely from the osseo-aponeurotic opening of adductor magnus to the lower border of popliteus muscle, where it terminates by dividing into anterior and posterior tibial arteries. The artery is relatively tethered at hiatus and again by the fascia related to soleus. Hence the artery is susceptible for traction damage during knee injuries.[1]

Variations of the popliteal artery have been the subject of repeated study. The embryonic development determines the anatomic variability[2]. In young adults, especially athletes with anomalous anatomic relationship between the popliteal artery and the musculotendinous structures, serious disabilities may result. A variant artery may pass beneath the head of gastrocnemius or an aberrant band, causing occlusion of the artery and leading to popliteal entrapment syndrome.[3]

The incidence of normal branching pattern of popliteal artery ranges between 92 - 96%. Variation of popliteal artery and its branching pattern may have clinical implications during vascular grafting, direct surgical repair, transluminal angioplasty, or embolectomy.

Involvement of variant arteries during surgeries can lead to arterial complications like transection, fistula formation, pseudoaneurysms. Moreover differentiating occlusion or arterial injury from variation depends upon clinician's knowledge of variation[4]. With the advent of newer diagnostic techniques like angiography, duplex ultrasound, MRA, CT angiogram, it is necessary to be aware of these variations to prevent misinterpretation of test results.

Knowledge of branching pattern of popliteal artery is of immense help to surgeons, as this vascular component is also approached during bypass surgeries for revascularization of lower limb, to relieve popliteal entrapment syndrome, patellar surgeries and also repair of anterior cruciate ligament tear. [4] With this perspective, the present study was undertaken, wherein the popliteal artery and its branching pattern was studied in detail.

METHODS

Materials used for the study was dissection instruments and synthetic Enamel Asian paint- Apcolite Asian paints Ltd Mumbai (P.O Red).

Source of data

Specimens were collected from the cadavers which were available in the department of anatomy, JSS medical college, Mysore, India.

Dissection method

The popliteal artery and its branches were studied in 40 lower limbs of embalmed human cadavers. The popliteal fossa was approached and the popliteal pad of fat was removed.

The tibial nerve, common peronealnerve, and popliteal vein were identified and were separated from the popliteal artery. Then the popliteal artery, its genicular branches, and terminal branches were traced. The level of termination and the mode of termination were noted. The popliteal artery and its branches were treated with acetone, painted using synthetic enamel Asian paints and photographed.

RESULTS

40 specimens were dissected and popliteal artery was observed for following details.

- The origin and level of termination of popliteal artery.
- Mode of termination of popliteal artery – bifurcation or trifurcation
- Course of popliteal artery
- Number and variations in the origin of genicular arteries.

Origin of popliteal artery

The popliteal artery was continuation of femoral artery in all the specimens studied.

Level of termination of popliteal artery

The level of termination of popliteal artery in relation to popliteus muscle was observed in all the specimens. Popliteal artery terminating at the lower border of popliteus muscle was considered as normal. The termination was considered high if it was at the upper border of popliteus muscle .It was considered as low termination if it was far below from the lower border of popliteus muscle. In all the 40 dissected specimens the popliteal artery terminated at the lower border of popliteus muscle.

Mode of termination

The mode of termintion of popliteal artery was classified according to the system used by Kim et al.

Normal mode of termination of the popliteal artery

- Usual pattern: anterior tibial is the first arterial branch;tibioperoneal artery follows and bifurcates into peroneal and posterior tibial arteries.
- Trifurcation: Anterior tibial, posterior tibial and peroneal arteries arise within 0.5cm; there is no tibioperoneal trunk.
- Anterior tibioperoneal trunk in which posterior tibial is the first branch, tibioperoneal trunk follows and bifurcates into peroneal and anterior tibial.

High division of popliteal artery

- Anterior tibial arises at or above the knee joint ie at the upper border of the popliteus muscle
    1. Normal course of proximal anterior tibial
    2. Medial initial curve in anterior tibial
- Posterior tibial arises at the upper border of popliteus. Common trunk for peroneal and anterior tibial.
- Peroneal arises at the upper border of popliteus. Common trunk for anterior and posterior tibial.

In the present study all the specimens belonged to type A pattern where anterior tibial is the first arterial branch; tibioperoneal artery follows and bifurcates into peroneal and posterior tibial. All the terminal branches were at the lower border of the popliteus muscle.

Course of popliteal artery

In all the 40 specimens studied, popliteal artery entered the popliteal fossa through the fifth opening in the adductor magnus. Along its course the artery passed downward in close contact with the floor of the popliteal

fossa, lying between the two heads of gastronemius muscle and superficial to the muscle. Then it descended laterally inclining obliquely to the distal border of popliteus muscle where it divided into ATA (anterior tibial artery) and PTA (posterior tibial artery) (Figure 1).

Table 1: Showing variation in origin of genicular branches.

Variation in genicular artery origin	No of specimens	Percentage
Common trunk for MGA, SLGA	Nil	nil
Common trunk for MGA, SLGA & SMGA	2	5%

Number and variatons in genicular branches

In the specimens studied there were 5 genicular branches SMGA, SLGA, MGA, inferior lateral genicular artery (ILGA), inferior medial genicular artery (IMGA).In two of the 40 dissected specimens the SMGA, SLGA and MGA were arising from a common trunk (Table 1) (Figure 2 and 3).

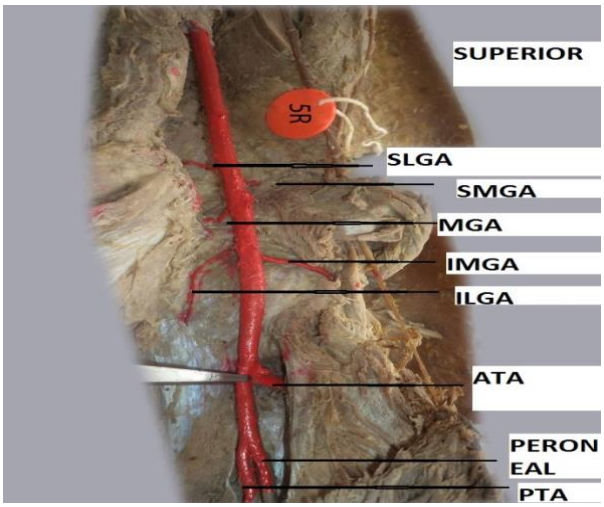

Figure 1: Normal branching pattern of popliteal artery in the specimen 5R.

Figure 2: Specimen no 10R common trunk for SMGA, SLGA and MGA.

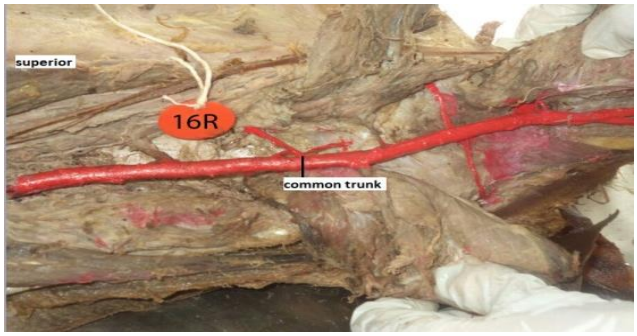

Figure 3: Specimen no 16R S common trunk for SMGA, SLGA and MGA.

DISCUSSION

The popliteal artery which is the continuation of femoral artery is the main and prime arterial supply to the knee, to the leg and foot. Because of its situation, its branches are vulnerable for injuries and damage. The genicular arterial anastomoses form intricate anastomoses, superficial and deep and these are the sources of nutrition to the joints, articular capsule and synovial membrane. The single middle genicular artery is susceptible for damage during the use of arthroscopy.[9] The terminations of popliteal artery are of variable types and the importance of termination may alter the origin of peroneal and inferior set of genicular arteries.

All the specimens studied by dissection method revealed normal origin, course and termination of popliteal artery. Popliteal artery terminating at the lower border of popliteus muscle was considered as normal. The termination was considered high if was at the upper border of popliteus muscle. It was considered as low termination if it was far below the lower border of popliteus muscle.

Highest incidence (10%) of high termination of popliteal artery was observed by Somayaji. They had highlighted racial differences in the incidence of high division of popliteal artery being 10% in subjects of Manipal zone of Karnataka as compared to 6.2% in American Negroes and 4.9% in American whites.[6] Tindall found high origin of ATA in 6% of cases. The previous cadaveric and angiographic studies have reported the prevalence of high origin of ATA to be 1.9% to 4.2%. Compared to this, in this study it was found to be higher.

In high origin, ATA passes beneath the popliteus and is in direct contact with the posterior surface of tibia. It is thus vulnerable for damage during knee arthroplasty or high tibial osteotomy.[18] In the arteriographic study done by Bradsly, he observed high division of popliteal artery in 4.2% (10/235), high division with the peroneal arising from the ATA in 1.7% of the cases. Variations in the pattern between limbs in same subject were also studied. Same pattern of division in both limbs was seen in 91.3%.[5]

A case was reportd of a 56yr old male presenting with pseudoaneurysm of ATA and compartment syndrome after total knee replacement. It was noted that, in this the anomalous high origin of ATA which is a known anomaly, resulted in being injured.[19]

Barut also noted the 3.57% of high termination cases in a cadaveric study. In this study though the sample size was less (28 popliteal fossa studied), the incidence found was more.[20] Mauro observed high origin of ATA passing either superficial or deep to the popliteus (2.3%), high termination of popliteal artrey with anterior tibioperoneal trunk (0.9%). Compared to other studies these findings were less in frequency (Table 2).[2]

Course of popliteal artery

In all the 40 dissected specimens studied, popliteal artery entered the popliteal fossa through the fifth opening in the adductor magnus. Along its course, the artery passed downward in close contact with the floor of the popliteal fossa, lying between the two heads of gastronemius muscle and superficial to popliteus muscle. Then it descended laterally inclinig obliquely to the distal border of popliteus muscle where it divided into ATA and PTA. In the case of persistent sciatic artery, it was noted that the popliteal artery coursed straight and was displaced somewhat laterlly than its usual course.[21]

Table 2: Comparison of level of termination (LOT) of popliteal artery found in earlier studies with that of present study.

Author	Normal LOT	High LOT	Low LOT	Method
Bardsley and Staple[5]	91.4%	5.9%	nil	Angiography
Mauro[2]	96.8%	2.3%	nil	Angiography
Kim[4]	95.34%	4.66%	nil	Angiography
Somayaji[6]	74.9%	10%	3.1%	Dissection
Tindall[18]	94%	6%	nil	Doppler
Barut[20]	96.3%	3.57%	nil	Dissection
Present study	100%	nil	nil	Dissection

Branching pattern of genicular arteries

In specimen no 16R and 10R the common stem at the level of femoral condyles trifurcated into superior medial, superior lateral and middle genicular arteries. In these specimens origin of inferior medial and inferior lateral genicular arteries were normal. Study done by Singla R on 60 lower limbs revealed 1% variation in genicular arteries where superio lateral and middle genicular artery shared a common trunk of origin.[8]

Similar findings have been observed by Salaria et al during dissection of 8 cadavers. They reported the origin of middle genicular artery 3-5 cm proximal to the joint line, either alone or having a common origin with superior lateral genicular artery (Table 3).[9]

Table 3: Comparision of variation in branching pattern of genicular arteries with that of present study.

Author	No of specimens studied	Method	Mode of branching pattern	
			Common trunk for MGA, SLGA	Common trunk for MGA, SLGA & SMGA
Reena Singla[8]	60	Dissection	1.6%	nil
Salaria and Atkinson[9]	8	Dissection	12.5%	Nil
Present study	40	Dissection	nil	5%

Mode of termination

The observed variants were trifurcation, anterior tibioperoneal trunk and absent PTA. The most common variant, trifurcation was noted by the entire author except the present study. All the terminal branches may arise from a single stem. ATA, PTA and peroneal arising within 0.5cm was considered as trifurcation. Trifurcation presents a particular technical challenge during angioplasty and embolectomy.[2] Awareness of these popliteal arterial variations is important for those performing surgical or percutaneous vascular reconstruction in the lower extremity. The distal popliteal arterial variations may influence the success of

femorodistal popliteal and tibial arterial reconstruction. Knowledge of an absent PTA or ATA may prevent false diagnosis of arterial damge in trauma when normal ankle pulses are absent or diminished.[2] In present study we had a limitation of 40 limbs and no variations were found in origin, or termination except for the genicular arteries. Further studies are required in this field to confirm the incidence of variation and termination of popliteal artery.

The popliteal artery is a commonly approahed site for above- or below-knee bypass grafts. It is also frequently injured by penetrating and blunt trauma of the lower extremity.Exposure of this artery is therefore, often required in both emergency and elective vascular procedures.[23] Knowledge of the anatomic variability in this region may have clinical implications and are very essential during vascular grafting, direct surgical repair, transluminal angioplasty, embolectomy, other arterial injury.[2] Awareness of the anatomical variations in the branching of the popliteal artery is important because damage to its branches may result in limb disability or life threatening haemorrhage.[18]

CONCLUSION

The following conclusion can be drawn after observing the results of the present study: Although no variation in branching pattern of popliteal artery has been found in the present study except for variations in genicular branches, an arteriogram done before approachng this region for vascular surgeries, can give us adequate information about the branching pattern and if any variations present. Prior knowledge of the possible variations is essential for competence in diagnostic and therapeutic procedures.

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