



VARIATIONS IN THE BRANCHING PATTERN OF POPLITEAL ARTERY AND IT'S CLINICAL IMPLICATIONS : A CADAVERIC STUDY

Ankit Khandelwal, Pooja Rani, Mahindra Nagar

Department of Anatomy, University College of Medical Sciences and GTB hospital, Dilshad Garden, New Delhi-110095.

ABSTRACT

Background: Due to the increasing number of surgical techniques used nowadays on the knee joint, the importance of the knowledge of the branching pattern of the vessels neighboring the joint becomes very significant. Anomalies of vascular patterns near the knee joint particularly the popliteal vessels, are therefore noteworthy in understanding the atypical clinical findings encountered while dealing with knee joint procedures. Popliteal artery, a continuation of femoral artery at the level of adductor hiatus, normally divides into anterior and posterior tibial arteries at the level of lower border of popliteus muscle.

Aim: This study attempts to analyze the level of division and as well as the branching pattern of the popliteal artery.

Methodology: A study on forty lower limbs of twenty embalmed human cadavers (twelve male and eight female cadavers/ twenty four male and sixteen female limbs) was carried out to find out the variations in the branching pattern of popliteal artery.

Results: We observed the high division of the popliteal artery proximal to the popliteus muscle along with the variations in the branches of the artery in two of the limbs (5%). The photographs of the variations were taken for proper documentation and ready reference. There were no other variations found in these specimens.

Conclusion: Variations in the branching pattern of the popliteal artery may increase the risk of complications during surgeries of the knee joint. The awareness of these variations is important during radiological examinations as they may affect the therapeutic approach by the surgeons and the interventionists.

Key Words: Axial artery, Peroneotibial trunk, Vascular surgery, Popliteus muscle, High division

INTRODUCTION

The popliteal artery, about twenty cm in length is the continuation of the femoral artery and it descends laterally from the opening in adductor magnus to the femoral intercondylar fossa, inclining obliquely to the distal border of popliteus, where it divides into the anterior and posterior tibial arteries. This division usually occurs at the proximal end of the asymmetrical crural interosseous space between the wide tibial metaphysis and the slender fibular metaphysis at the level of lower border of popliteus¹. Posterior tibial artery is the larger of the two terminal branches and enters the posterior compartment of leg under cover of tendinous arch of origin of soleus. This artery gives a large branch, the peroneal artery nearly 2.7 cm distal to its origin. The popliteal artery besides its two terminal branches gives off cutaneous, muscular and genicular branches and ends beneath the flexor

retinaculum by dividing into medial and lateral plantar arteries. The other terminal branch, the anterior tibial artery passes between the two heads of tibialis posterior and enters the anterior compartment of leg through an oval gap above the interosseous membrane. It then continues as dorsalis pedis artery between the medial and lateral malleoli.

The popliteal artery may divide proximal to the inferior border of popliteus muscle then being termed as high division of the popliteal artery and may trifurcate into anterior tibial, posterior tibial and peroneal artery.

The popliteal artery acts as a common 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, frequently required in both emergent and elective vascular procedures². Knowledge of the anatomical variation in this re-

Corresponding Author:

Dr. Ankit Khandelwal, Senior Resident Department of Anatomy University College of Medical Sciences,

E-mail: akdrankitkhandelwal@gmail.com

Received: 30.06.2014 **Revised:** 22.07.2014 **Accepted:** 19.08.2014

gion may have clinical implications regarding vascular grafting, direct surgical repair, embolectomy, transluminal angioplasty, or the diagnosis of arterial injury³. Also, knowledge of the variant patterns of branching of the popliteal artery is important since damage to its branches can be limb or life threatening⁴. Thus the present study is an attempt to add to the existing knowledge of the popliteal artery branching pattern variations.

MATERIALS AND METHODS

Over a span of two years (2012-14) a study was conducted on popliteal regions of forty formalin fixed cadaveric limbs (twenty four males, sixteen females) in the dissection hall of Anatomy Department of University College of Medical Sciences, Dilshad Garden, Delhi, India. Medical history and cause of the death of these cadavers was known. Dissection instruments were used to dissect the popliteal regions according to the dissection steps given in Cunningham's manual of practical anatomy⁵.

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. Any deviation from the normal was noted and discussed.

RESULTS

Out of the forty cadaveric limbs dissected and examined, no abnormality was detected in thirty eight limbs i.e. which showed normal pattern of division of popliteal artery. But there were two limbs which showed abnormalities in the branching pattern of popliteal artery (5%). The first abnormality was observed in a fifty five years old female cadaver on the right side, where the popliteal artery continued as the posterior tibial artery and gave off a common trunk named as anterior peroneotibial trunk slightly above the proximal border of popliteus muscle (Fig. 1). The length of the popliteal artery when measured was 10.5 cm in contrast to normal value of approximately twenty cm. The diameter of the anterior peroneotibial trunk appeared larger as it traversed the posterior surface of popliteus muscle for about 8.5 cm and then gave off the peroneal artery just before the anterior tibial artery passed through the oval gap in the interosseous membrane to come on the anterior surface of interosseous membrane. The further course of anterior tibial, posterior tibial and peroneal arteries was found to be normal which divided into anterior tibial and peroneal artery. Another variation was observed in a sixty years old female cadaver on the left side where the popliteal artery divided into anterior and posterior peroneotibial

trunks proximal to popliteus muscle (Fig. 2). In this limb the length of the popliteal artery was twelve cm in contrast to normal value of approximately twenty cm. The anterior tibial artery crossed posterior to the popliteus muscle and entered the extensor compartment of leg. Posterior peroneotibial trunk was long, measuring about 8.6 cm before it gave off the peroneal artery which normally arises after 2.7 cm. The further course of anterior tibial, posterior tibial and peroneal arteries was found to be normal.

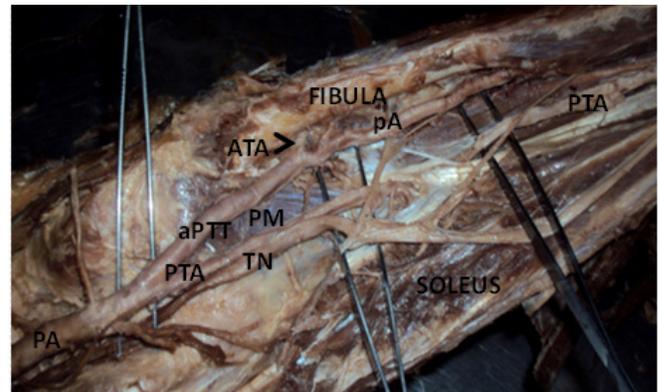


Figure 1: A dissected specimen of back of right leg showing popliteal artery (PA) dividing into its terminal branches – posterior tibial artery (PTA) and anterior peroneotibial trunk (aPTT) above the proximal border of the popliteus muscle (PM). PTA is seen traversing deep to the Soleus muscle. The anterior peroneotibial trunk (aPTT) is dividing into anterior tibial artery (ATA) and peroneal artery (pA). Tibial nerve (TN) and Fibula bone are also seen.

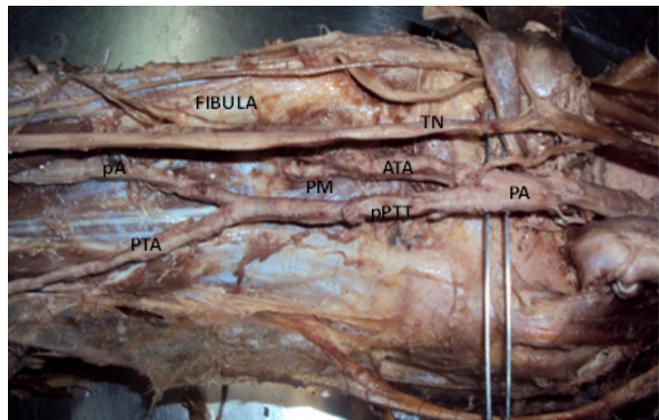


Figure 2: A dissected specimen of back of left leg showing popliteal artery (PA) dividing into its terminal branches – anterior tibial artery (ATA) and posterior peroneotibial trunk (pPTT) at the level of the proximal border of the popliteus muscle (PM). The posterior peroneotibial trunk (pPTT) is dividing into posterior tibial artery (PTA) and peroneal artery (pA). PTA is seen traversing deep to the Soleus muscle. Tibial nerve (TN) is also seen along with Fibula bone.

DISCUSSION

Variations in the branching of the popliteal artery are mainly targeted around the high division of the artery and the resulting differences in the arrangement of the terminal branches, posterior tibial, anterior tibial and peroneal arteries⁶. According to Adachi⁷ 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” and reported high division in 2.8% specimens.

In our study the popliteal artery branched at or slightly above the proximal border of the popliteus muscle in two cases (5%) this is in consonance with Keen observations, whereas percentages of high division of popliteal artery are considerably higher in American and European data. Thane (1892)⁸ has cited a case in which the popliteal artery extended to the middle of the back of the leg before dividing.

The high level termination of the popliteal artery in relation to the upper border of the popliteus muscle was grouped into three types by Adachi. In type I the popliteal artery descended on the posterior surface of the popliteus muscle and divided into the posterior peroneotibial trunk and the anterior tibial artery. The posterior peroneotibial trunk further divided into the peroneal artery and the posterior tibial artery. The diameter of the anterior tibial artery was equal to the popliteal artery or smaller than the posterior peroneotibial trunk. In type II the popliteal artery descended on the posterior surface of the popliteus muscle and divided into the posterior tibial artery and the anterior peroneotibial trunk. The diameter of the anterior peroneotibial trunk was observed to be larger and it divided into the peroneal artery and anterior tibial artery at the lower border of the popliteus muscle. In type III the popliteal artery terminated at the upper border of the popliteus muscle by dividing into the anterior tibial artery and posterior peroneotibial trunk. The anterior tibial artery ran downward in between the anterior surface of the popliteus muscle and the posterior surface of the tibia. The posterior peroneotibial trunk ran on the posterior surface of the popliteus muscle. The posterior peroneotibial trunk divided into the peroneal artery and posterior tibial artery distal to the tendinous arch of soleus muscle.

In the present study in one case the diameter of the anterior peroneotibial trunk appeared larger than normal. The average length of the popliteal artery was 11.2 cm in contrast to normal length of twenty cm. The anterior peroneotibial trunk was 8.5 cm long and traversed the posterior surface of popliteus muscle before it divided into anterior tibial artery and peroneal artery. The peroneal artery was given off just before the anterior tibial artery pierced the interosseous membrane to come onto the anterior surface of interosseous membrane. This is

in accordance with Adachi's type II, popliteal artery. In the second case the popliteal artery divided into anterior and posterior peroneotibial trunk proximal to popliteus muscle which is in accordance with the Type I of Adachi's classification of popliteal artery. The anterior tibial artery crossed posteriorly to the popliteus muscle and entered the extensor compartment of leg. The high origin of anterior tibial artery at or above the level of the articular surface of the tibial plateau is documented in literature. Another radiological study of the femoral angiograms on 495 lower extremities was performed to view the tibial arterial anatomy, and found that 7.8% of the cases revealed variations. Normally the diameter of the posterior tibial artery is more than the diameter of the peroneal artery, but in the present case the diameter of the peroneal artery appeared more than the diameter of the posterior tibial artery which is similar to the study of Ozgur et al⁹. It was reported in literature that the course of anterior tibial artery may either be from the anterior or posterior surface of the popliteus muscle. In the present cases the course of posterior tibial artery was on the posterior surface of the popliteus muscle.

Another variation of the popliteal artery is trifurcation, where all the three terminal branches arise together at the level of the lower boundary of the popliteus muscle. Trifurcation of the popliteal artery into anterior tibial, posterior tibial and peroneal branches was observed in 0.8% specimens (Adachi, 1928) and in 4.3% in Keen's study (1961), but it is not observed in the present study. 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. 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 specimens¹⁰. Agenesis of the popliteal artery, although obviously extremely rare, has been reported¹¹. Clinicians and radiologists have defined a different terminology of the popliteal artery and its main branches in popliteal surgery. The anterior tibial artery was defined as the tibial-fibular trunk as soon as it branched from the popliteal artery. The tibial arteries were referred to as anterior or posterior peroneotibial trunk depending upon the origin of the peroneal artery. In the present study in one of the cases the peroneal artery was given off from the anterior tibial artery and hence the anterior tibial artery may be defined as the tibial – fibular trunk.

EMBRYOLOGICAL BASIS

The axis artery of the lower limb is the *arteria ischiadica* in the embryo before the 14 mm stage. 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 proximodistal 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. However, it can be easily understood that, if the proximodistal fusion of the posterior tibial and peroneal vessels is abbreviated, the peroneal artery can consequently arise from the anterior tibial rather than from the posterior tibial¹².

The knowledge of branching pattern of the popliteal artery is important for surgical interventions in the popliteal region in order to minimize the unwanted hemorrhage and surgical complications due to anatomical variations. These anatomical variations should be kept in mind by orthopaedicians doing knee joint surgery and total knee arthroplasty, by surgeons operating on aneurysms of popliteal artery and by radiologists performing angiographic study. These variations are compared with the earlier data and it is concluded that variations in branching pattern of the popliteal artery are frequent rather than exceptions. 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.

CONCLUSIONS

Variations in the branching pattern of the popliteal artery may increase the risk of complications during surgeries of the knee joint. The awareness of these variations is important during radiological examinations as they may affect the therapeutic approach by the surgeons and the interventionists. Thus the present study is an attempt to add to the existing knowledge of the popliteal artery branching pattern variations.

ACKNOWLEDGEMENT

Authors acknowledge the immense help received from the scholars whose articles are cited and included in references of this manuscript. The authors are also grateful to authors / editors / publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed.

REFERENCES

1. Standring S. Gray's anatomy. The Anatomical basis of clinical practice. In: Mahadevan V. Knee. 40th ed. Elsevier. Churchill livingstone; 2008. p. 1393-1410.
2. Colborn G L, Lumsden A B, Taylor B S, Skandalakis J E. The surgical anatomy of the popliteal artery, *The American Surgeon*. 1994; 60: 238-246.
3. Mauro M A, Jaques P F, Moore M. The popliteal artery and its branches: embryologic basis of normal and variant anatomy. *Am J Radiol*. 1988; 150: 435-437.
4. Tindall J, Shetty A A, James K D, Middleton A, Fernando K W K. Prevalence and surgical significance of high-origin anterior tibial artery. *J Orthop Surg*. 2006; 14: 13- 16.
5. Romanes G J. Cunningham's manual of practical anatomy. In: popliteal fossa Vol. 1. 15th ed. Oxford, Oxford Medical Publications; p. 160-165.
6. Keen J A. A study of the arterial variations in the limbs with special reference to symmetry of vascular patterns. *Am J Anat*. 1961; 108: 245-261.
7. Adachi B. Das Arteriensystem der Japaner, Vol. II. Maruzen, Kyoto, 1928 pp 137-269.
8. Thane G D. Arthrology Myology Angiology. In: Schafer E A, Thane G D (editors). Quain's Elements of Anatomy. 10th ed. Longmans, Green and Co., London, 1892, pp 495
9. Ozgur Z, Ucerler H, Aktan I Z A. Branching patterns of the popliteal artery and its clinical importance. *Surg Radiol Anat*. 2009; 31: 357-362.
10. Lippert H, Pabst R. Arterial variations in man: Classification and frequency. Bergmann Verlag, Munich. 1985; 60-64.
11. Senior H D. The development of the arteries of the human lower extremity. *Am J Anat*. 1919; 25: 55-95.
12. Neville R F, Franco C D, Anderson R J. Popliteal artery agenesis: A new anatomic variant. *J Vasc Surg*. 1990; 12: 573-576.