

Anatomic study of infrapopliteal vessels

D. Lappas¹, N.A. Stavropoulos¹, G. Noussios², V. Sakellariou¹, P. Skandalakis¹

¹Department of Anatomy of National and Kapodistrian University of Athens, Greece

²Laboratory of Anatomy of Department of Physical Education (at Serres), Aristotelian University of Thessaloniki, Greece

[Received 20 March 2012; Accepted 9 May 2012]

The purpose of this project is to study and analyse the anatomical variations of the infrapopliteal vessels concerning their branching pattern. A reliable sample of one hundred formalin-fixed adult cadavers was dissected by the Anatomical Laboratory of Athens University. The variations can be classified in the following way: the normal branching of the popliteal artery was present in 90%. The remainder revealed variant branching patterns: hypoplastic or aplastic posterior tibial artery and the pedis arteries arising from the peroneal (3%); hypoplastic or aplastic anterior tibial artery (1.5%); and the dorsalis pedis formed by two equal branches, arising from the peroneal and the anterior tibial artery (2%). The variations were more frequent in females and in short-height individuals. Knowledge of these variations is rather important for any invasive technic concerning lower extremities. (Folia Morphol 2012; 71, 3: 164–167)

Key words: anterior tibial artery, posterior tibial artery, peroneal artery, anatomical study

INTRODUCTION

The vascular system has a large number of anatomical variations. Although many of these variations do not cause problems in daily life, they are rather interesting not only for vascular, orthopaedic, and plastic surgeons but also for radiologists, particularly in the lower limbs, where surgical arterial reconstruction, transluminal angioplasty, and embolectomy demand knowledge of these variation patterns. Furthermore, it is also well known that the fibula is used as a donor site for composite vascular bone grafts used in post-operative deficits of the mandible, after excision of large excision facio-maxillary tumours, as well as deficits in other parts of the body (i.e. forearm and arm). In the reconstruction of soft tissue defects it remains a challenge to seek alternatives with a higher success rate.

In 1985 Lippert and Pabst [7] classified the branching patterns of the popliteal artery accord-

ing to the level and the sequence of the branching of the anterior tibial (AT), posterior tibial (PT), and peroneal (PR) arteries. Several years later in 1989, Kim et al. [6] proposed a new classification of the branching pattern of the distal popliteal artery and the following infra popliteal vessels by modifying Lippert's system. In Kim's classification, attention paid to the predictability of the variations in the arterial supply to the foot is based on the appearance of the proximal tibial artery. Published literature has been limited to the study of a single extremity, and less is known about cadaver studies. We aim to present the results of our anatomical study.

MATERIAL AND METHODS

The study was approved by the Athens Medical Jurisprudence Revenue. One hundred human embalmed formalin-fixed adult cadavers (200 legs) were used: 54 male and 46 female with an age range of

Address for correspondence: G. Noussios, MD, PhD, Ass. Prof., Laboratory of Anatomy of Department of Physical Education (at Serres), Aristotelian University of Thessaloniki, Vassileos Georgiou 34, 546. 40 Thessaloniki, Greece, tel: +30 2310855012, fax: +30 2310830101, e-mail: geornous@hotmail.com

22–76 years old (average age 57.4 years). We performed dissections of each leg of the cadavers resulting in a total of 200 legs. Layer-by-layer dissection method was used. The cadavers were placed in a supine position with the knee slightly flexed. An H-shaped incision was made starting from the posterior aspect of the knee down to the third metatarsal space, including skin, subcutaneous tissue, and deep fascia. The surface of the gastrocnemius muscle was exposed, and after incision of the Achilles tendon the posterior tibial and soleus muscle were revealed. The popliteal, AT, PT, and PR arteries and their perforating branches, superficial PR nerve and its accessory artery, superior lateral PR artery, inferior lateral PR artery, and septocutaneous perforator origin from the AT artery were all assessed (Figs. 1, 2).

RESULTS

Of the 200 cadaveric limbs, 180 extremities ($n = 180/200 = 90\%$) followed the normal anatomical branching pattern of the infrapopliteal arteries, according to which the AT artery is the first arterial branch followed by the tibioperoneal trunk, which bifurcates into the PR and the PT arteries (Fig. 3A). Hypoplastic or aplastic PT and distal PT were replaced by the PR ($n = 2/200 = 1\%$) (Fig. 3B). Hypoplastic or aplastic AT ($n = 3/200 = 1.5\%$) and the dorsalis pedis artery were formed by the PR artery (Fig. 3C). Hypoplastic or aplastic PT ($n = 3/200 = 1.5\%$) and distal PT were replaced to PR (Fig. 3D).

The variability of the nutrient branches was also rather interesting. Almost 50% of them took off from the tibioperoneal trunk with certain implications in the tissue morphology. Variations were more commonly identified in women ($p = 0.012$). Furthermore, the distribution of the variations according to height was also studied and it was revealed that persons of a height below 1.50 m were more prone to a variation branching pattern (Fig. 4).

DISCUSSION

This review of the infrapopliteal arteries branching patterns was motivated by the potential hazards and the required knowledge for surgeons performing operation reconstruction procedures in lower extremities. Despite improvements in reconstruction surgery, popliteal vascular injuries continue to be potentially dangerous lesions. Variations seem to be the result of embryological abnormalities of the arterial network of the lower limb. Development of the arterial network commences in the 9-mm embryo and is completed in

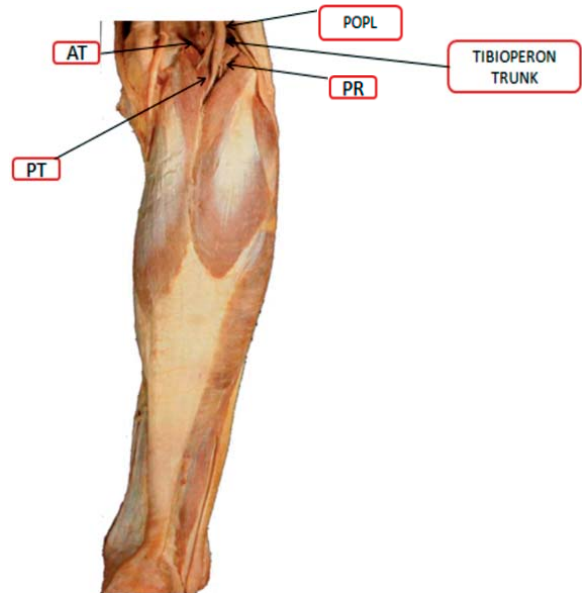


Figure 1. Popliteal artery (POPL), anterior tibial (AT), posterior tibial (PT), peroneal (PR) artery, and tibioperoneal trunk (TIBIOPERON TRUNK).

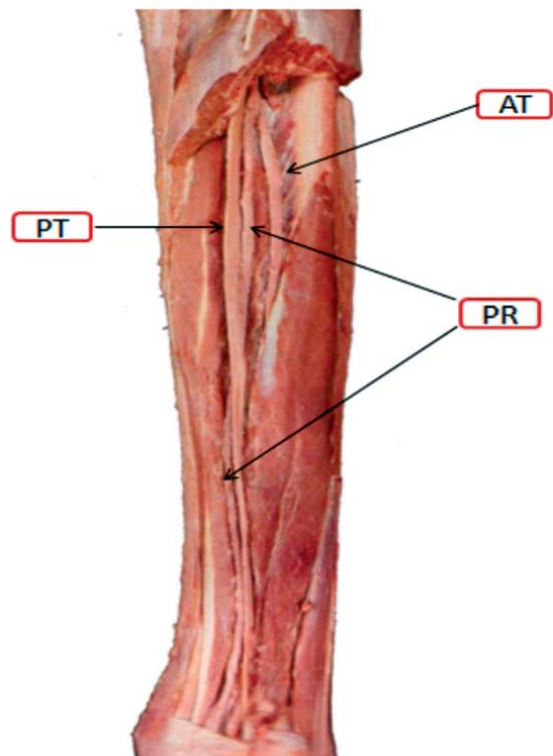


Figure 2. Anterior tibial (AT), posterior tibial (PT), and peroneal artery (PR).

the third month [5, 10]. The lower extremity vessels derive from two vessels: the inferior gluteal or axial artery, which arises from the dorsal root of

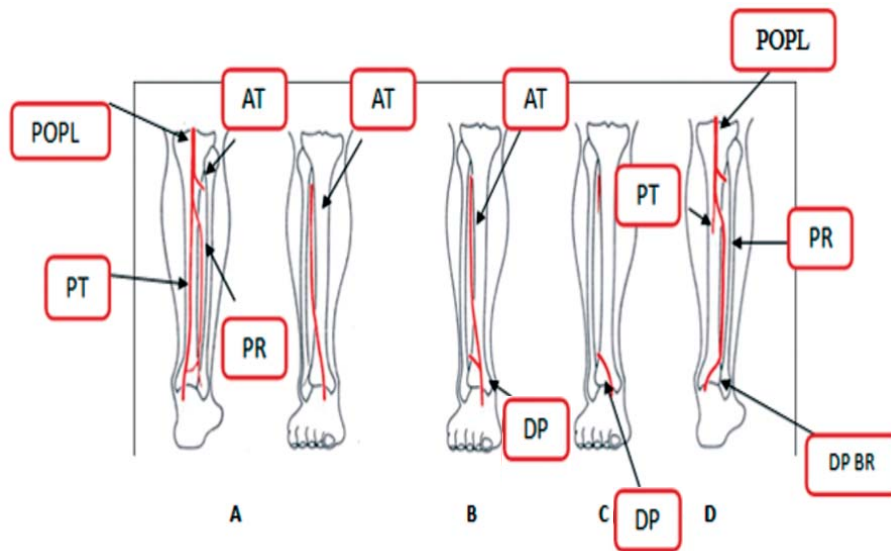


Figure 3. Types of variations of anatomical branching pattern of infrapopliteal arteries (A, B, C, D); AT — anterior tibial artery; PT — posterior tibial artery; PR — peroneal artery; POPL — popliteal artery; DP — dorsalis pedis; DP BR — dorsalis pedis branch (peroneal artery branch to formation of dorsalis pedis).

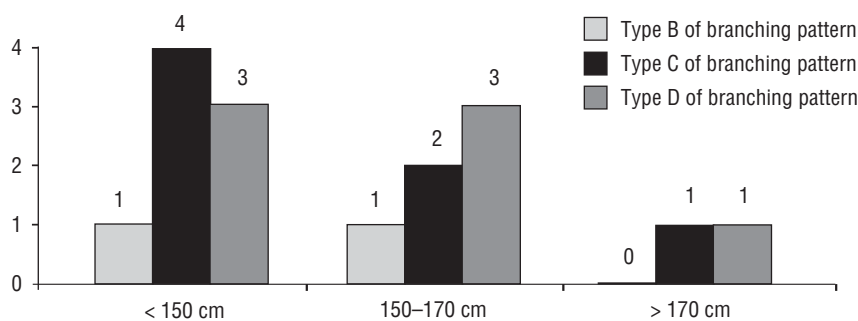


Figure 4. Distribution of the variations anatomical branching pattern (types: B, C, D) of the infrapopliteal arteries according to height.

the umbilical artery and runs through the thigh below the knee between the tibia and popliteus femoral artery, a branch of the external iliac artery [4, 8, 11]. By the 14-mm embryonic stage, the femoral artery becomes the major supply artery to the lower limb as it has anastomosed with the inferior gluteal artery [1, 5, 10]. The middle and distal segments of the inferior gluteal artery form the definitive popliteal and PR arteries [5]. The AT arises from the popliteal artery and more specifically from the ramus communicans, which is a perforating branch arising from the distal border of the popliteus and communicates with the femoral from the inferior gluteal artery [1, 4, 5, 8, 10, 11]. The popliteal artery and the distal femoral artery form the PT [1, 5, 10]. Persistent primitive arterial segments, abnormal fusions, segmental hypoplasia, or the absence of some of these arteries, explain the anatomical

variability [1, 10]. In order to explain the anatomical variations of the lower limb, the following should be considered: the AT artery is a more recent artery — concerning angiogenesis; the PR is the earlier vascular branch, while it constitutes a continuation of the posterior axis vascular retinaculum; and the tibial arteries become enlarged replacing the PR artery when blood flow comes to the end part of the lower limb.

Lypert's classification system was fundamental for description of the classification and the frequency of vascular variations [7]. Kim et al. [6] proposed a new classification by modifying Lypert's classification. They classified the patterns into three categories, and each of these into three subtypes. According to the usual pattern described by Kim et al. [6], (IA) the AT is the first arterial branch; the tibioperoneal artery follows, divided into the PR and the PT

arteries (92.2%); (IB) the AT, PR, and PT arise within 0.5 cm (2%); the PT is the first branch followed by the anterior tibioperoneal trunk that bifurcates into the PR and AT (1.2%).

In type II, the popliteal artery has a high division; (IIA) when the AT arises above the knee joint (3.7%); (IIB) when the PT arises at or above the knee joint and the PR and AT are present with a common trunk (0.8%) and (C) when the PR arises at or above the knee joint (0.16%).

Additionally, the type III pattern is rather interesting as IIIA includes hypoplastic or even aplastic PT, while distal PT is replaced by PR; (IIIB) hypoplastic or aplastic PT and AT while the dorsalis pedis (DP) is replaced by the PR (1.6%) and (IIIC) presenting with hypoplastic or aplastic both the PT and AT, while the PT and DP is replaced by the PR (0.2%).

The variations presented in our study can be classified in the following way: the normal IA branching of the popliteal artery was present in 90% of cases. The AT artery is the first arterial branch and originates from the popliteal artery at the lower border of the popliteus muscle. The tibioperoneal trunk follows and bifurcates into the posterior tibial and the PR artery. Cross et al. [2] and Ozgur et al. [9] presented a normal branching pattern of the popliteal artery in 92% of cases. Furthermore, Day and Orme [3], using their angiographic results, presented 90.7% of usual branching pattern.

The remainder reveal variant branching patterns: hypoplastic or aplastic PT artery and the pedis arteries arising from the PR artery (3%); hypoplastic or aplastic AT artery (1.5%); the DP is formed by two equal branches, arising from the PR and the AT arteries (2%).

It is important to recognise vascular branching patterns for planning any type of radiological or

surgical intervention. This is particularly true when rare type III branching patterns are present. Therefore, knowledge of these patterns and a careful examination is advisable to prevent arterial injury.

REFERENCES

1. Arey LB (1974) Developmental anatomy. In: A textbook and laboratory manual of embryology. 7th Ed. Saunders, Philadelphia, pp. 358–360.
2. Cross L, Hall J, Howdieshell TR, Colborn GL, Gale TF (2000) Clinical anatomy of the popliteal blood vessels. *Clin Anat*, 13: 347–353.
3. Day CP, Orme R (2006) Popliteal artery branching patterns: an angiographic study. *Clin Radiol*, 61: 696–699.
4. Jung W, Oh CS, Won HS, Chung IH (2008) Unilateral arteria peronea magna associated with bilateral replaced dorsalis pedis arteries. *Surg Radiol Anat*, 30: 449–452.
5. Kil SW, Jung GS (2009) Anatomical variation of the popliteal artery and its tibial branches: analysis in 1242 extremities. *Cardiovasc Intervent Radiol*, 32: 233–240.
6. Kim D, Orron DE, Skillman JJ (1989) Surgical significance of popliteal arterial variants. A unified angiographic classification. *Ann Surg*, 210: 776–781.
7. Lippert H, Pabst R (1985) Arterial variations in man: classification and frequency. In: Bergmann JF ed. Verlag, Munchen, pp. 54–63.
8. Mavili E, Donmez H, Kahrman G, Ozaslamaci A, Ozcan N, Tasdemir K (2011) Popliteal artery branching patterns detected by digital subtraction angiography. *Diagn Interv Radiol*, 17: 80–83.
9. Ozgur Z, Ucerler H, Ikiz ZAA (2008) Branching patterns of the popliteal artery and its clinical importance. *Surg Radiol Anat*, 31: 357–362.
10. Senior HD (1919) The development of the arteries of the human lower extremity. *Am J Anat*, 25: 55–94.
11. Tindall AJ, Shetty AA, James KD, Middleton A, Fernando KW (2006) Prevalence and surgical significance of a high-origin anterior tibial artery. *J Orthop Surg (Hong Kong)*, 14: 13–16.