

New Patterns of the Popliteal Artery and its Branches in Thais

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ABSTRACT

This study aimed to investigate the anatomical patterns of popliteal artery (PA) in terms of normal and variation patterns in Thais. Two hundred and thirty legs of preserved human cadavers were dissected, and the pattern of PA and its branches were identified by Kim's classification. Pattern I-A was mostly found (88.7%), pattern I-B (modified) found 0.4%, pattern I-C (modified) found 4.8%, pattern II-A1 and pattern II-B found 0.9%, pattern II-A2 found 1.3% and pattern II-D (modified) no result in Thais. Two newer patterns were found: pattern new-1 found 0.9%, and pattern new-2 found 2.2%. Compared between genders and sides, all variations showed no significant difference. Regarding undertaking operative or interventional procedures within the leg, this knowledge could be applied to prevent complications during the surgical approach or percutaneous vascular assessment and might be one of the references of variation of these vessels in Thais.

Keywords: Popliteal artery (PA), Anterior tibial artery (ATA), Posterior tibial artery (PTA), Peroneal artery (PRA)

Siriraj Med J 2013;65:47-50

E-journal: <http://www.sirirajmedj.com>

INTRODUCTION

Vascular anatomy has a strong influence on the choice of surgical approach. Anomalies of vascular patterns may explain uncharacteristic physical or clinical findings.¹ The importance of the branching patterns of the popliteal artery (PA) in surgery has been evaluated by different techniques such as dissection and angiography. So far, there are many types of anatomical variations in PA. Those reports were studied in many races, but not in Thais. Popliteal artery (PA), the continuation of the femoral artery, begins when this artery passes through the adductor hiatus in adductor magnus muscle. The PA passes inferolaterally through the popliteal fossa and ends at the inferior border of the popliteus muscle (PM) by dividing into the anterior tibial artery (ATA) and the posterior tibial artery (PTA).²

PA injury can occur in 30%-50% of cases of complete knee dislocation.³ The types of arterial damage sustained during these injuries include intimal injury, avulsion, occlusion, or aneurysm formation that may be

complicated by rupture or the formation of thrombosis or emboli. PA trauma is usually obvious in open knee injuries, but recognition of arterial injury after blunt knee injuries is usually delayed. If the extent of the injury causes flow interruption in the PA, patients may complain of pain, paresthesias, or loss of sensation or motor function distal to the knee. More commonly, injury creates an intimal flap with initial preservation of flow and complete lack of symptoms.⁴ Arterial injury can result in limb loss. If there are obvious signs of limb ischemia, immediate surgical intervention is required, because ischemia for more than 4-6 hours can cause irreversible neurologic damage and muscle necrosis, which in turn has been shown to correlate with adverse outcomes, including limb loss.⁵ Standard management includes surgical revascularization such as primary repair and, more commonly, a short bypass with a saphenous vein graft.⁶ If ischemia is prolonged for several hours, fasciotomies to treat or prevent compartment syndrome are mandatory.⁴ An ATA usually branches off the PA at the distal border of the PM and provides blood to the anterior compartment of the lower limb and the dorsum of the foot. The ATA is particularly susceptible to injury with trauma of the anterolateral knee, shin, and ankle.⁴ Kim⁷ classified a branching pattern of the PA according to Lippert's classification⁸ the level and sequence of the branching of the ATA, PTA and PRA, and whether they were aplastic, hypoplastic or neither. Kim

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Received 30 July 2012

Revised 17 September 2012

Accepted 21 September 2012

TABLE 1. Numbers and Frequency of Popliteal Arterial Variations in Thais.

		Numbers of patterns								
		IA	IB (modified)	IC (modified)	IIA1	IIA2	IIB	IID (modified)	New-1	New-2
Male	117	107	0	6	0	1	0	0	0	3
Female	113	97	1	5	2	2	2	0	2	2
		Percentage of patterns								
		IA	IB (modified)	IC (modified)	IIA1	IIA2	IIB	IID (modified)	New-1	New-2
230		88.7	0.4	4.8	0.9	1.3	0.9	0	0.9	2.2

Patterns of PA compared between genders and sides were not statistical significant difference in both groups. (p-value=0.328 and p-value = 0.350 respectively)

et al.,⁷ described another classification based on angiographic appearances with a modification of the classification by Lippert et al.⁸ According to this classification, the division of the PA was at the normal level (below the tibial plateau) in type I branching pattern of the PA. Type II branching pattern of the PA is presented when one of the branches arise above the tibial plateau.⁹

In this study, we classified and related variation patterns of the PA and the tibial arterial distribution to the lower leg (classification of popliteal arterial variation suggested by Kim).⁷ Knowledge and information of anatomical variation of PA in Thais should be considered because injury to its branches can cause limb- or life-threatening condition. This knowledge could be applied to prevent complications caused by endovascular therapy. A review of the anatomic characteristics of the PA and its branches will be beneficial for surgical approaches and the choice of suitable arterial graft sites.⁹ The collected and analyzed data might be applied for clinical investigation and reconstructive surgery and referenced for variation of these vessels in Thais.

MATERIALS AND METHODS

Materials

All 230 legs of 116 Thai cadavers were studied, 59 males and 57 females with the ages ranged from 32 to 101 years (average 71.52 years). These preserved cadavers were provided by the Department of Anatomy, Faculty of Medicine Siriraj Hospital, Mahidol University and Department of Anatomy, Faculty of Science, Mahidol University. The using of cadavers is exempted by the Siriraj Institutional Review Board.

Methods

Regarding our cadaveric study, a series of 230 legs of the 116 cadavers were selected. The skin and superficial fascia were incised and reflected. The PA in accordance with ATA, PTA and PRA were dissected, and their origins and courses were carefully identified. The relation of the origin of the ATA and the PTA from the PA were recorded. The original sites of the ATA, PTA and PRA were studied. Then, the patterns of all these four vessels were classified by their branching pattern of the PA based on Kim's classification which was defined as follows:

Pattern I-B of Kim's classification changed to I-C (modified).

Pattern I-C of Kim's classification changed to I-B (modified).

And Pattern II-C of Kim's classification changed to II-D (modified).

The differences in regards to their genders and sites were compared (based on Kim's classification) (Fig 1). Chi-square statistical analysis was applied for the pattern of the vessels ($\alpha=0.05$) and unpaired t-test.

RESULTS

The results of the study of 230 legs (117 legs in male and 113 legs in female) in 116 human preserved cadavers have been shown: (Table 1)

Normal level of popliteal arterial branching: the first arterial branch arises lower to the PM. (Fig 1)

High division of popliteal artery: the first arterial branch arises at or above the knee joint. (Fig 1)

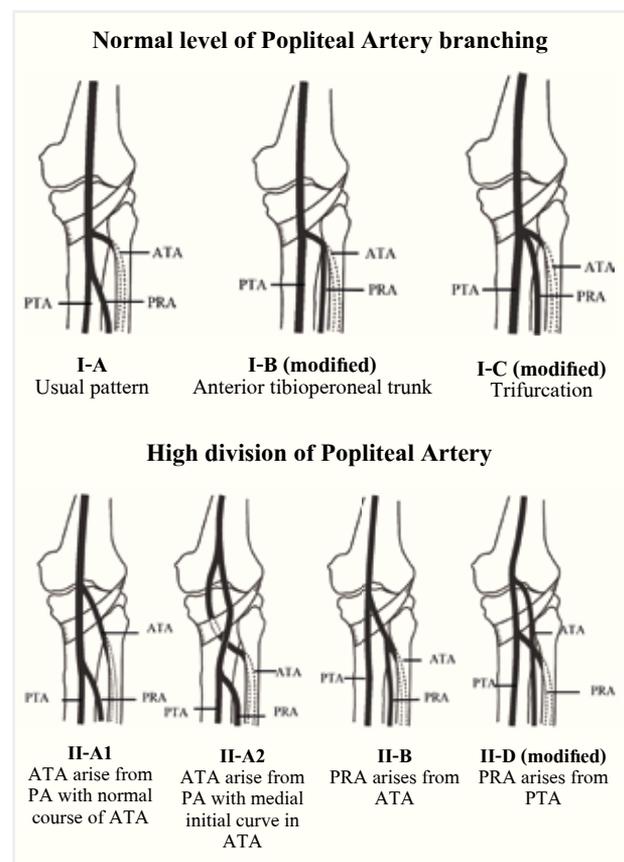


Fig 1. Modify classify branching pattern of the popliteal artery (PA) based on Kim's classification (ATA= anterior tibial artery, PRA=peroneal artery, PTA=posterior tibial artery)

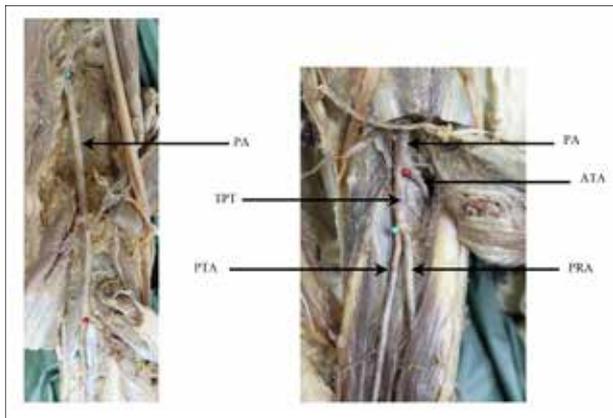


Fig 2. An example specimen of right leg shows all five landmark arteries (Posterior view) (PA=popliteal artery, ATA=anterior tibial artery, TPT=tibioperoneal trunk, PTA=posterior tibial artery, PRA=peroneal artery)

The new patterns

1. The new pattern-1 was found in two legs (0.9%). (Table 1) The PA posteriorly divides to the inferior border of the PM by giving off the ATA and the PRA. The ATA courses laterally toward the fibula before running down the calf to terminate as the dorsalis pedis artery. This pattern showed no PTA. The PTA was replaced by the PRA. The PRA runs down the posterior calf and terminates at the level of the calcaneus by bifurcating into the medial and lateral plantar arteries (Fig 3).

2. The new pattern-2 was found in five legs (2.2%) (Table 1). This was absent from the few patterns reported in literature. The PA posteriorly divides to the inferior border of the PM by giving off the ATA, which courses laterally toward the fibula before running down the calf to communicate with lateral plantar artery. Short TPT terminates to the PTA and the PRA. The PTA is much smaller than the PRA and tapers distally. At the ankle, the dorsalis pedis artery is formed by communicating between the ATA and the PRA. This pattern is similar to the pattern III-C; hypoplastic-aplastic PTA and ATA of Kim et al.,⁷ but differs to ATA communicating with PRA. (Fig 3)

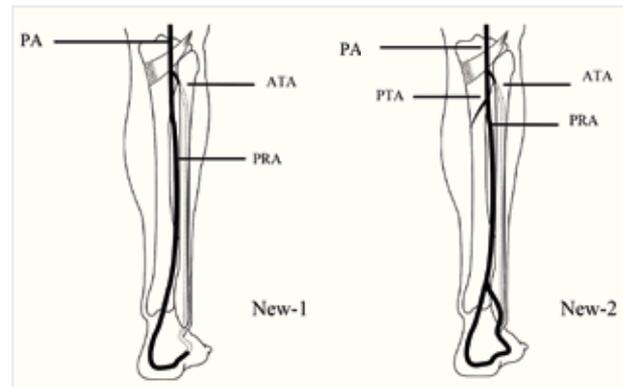


Fig 3. Diagram shows the new patterns (Posterior view) (PA=popliteal artery, ATA=anterior tibial artery, PTA=posterior tibial artery, PRA=peroneal artery)

DISCUSSION AND CONCLUSION

Despite improvements in vascular surgical techniques, popliteal vascular injuries and PA aneurysms remain notorious high-risk lesions causing a high percentage of leg amputations. Even though knee arthroscopy is a minimally invasive procedure and injury of a popliteal artery during orthopedic knee surgery is very rare, the injury to the PA may result and has serious consequences.^{10,11} Dar et al.,¹² demonstrated that 24.6% of patients with PA injury had associated bone fracture. Although the anatomy of PA, ATA, PTA and PRA have been previously described, there is no record in Thais. We have followed the criteria of PA variations in patterns as described by Kim et al.⁷ This review of popliteal and tibioperoneal arterial variations was initiated by technical difficulties encountered during arterial reconstruction in patients who underwent femorodistal bypass graft procedures.⁷ The results of this study have demonstrated that pattern I-A in Thais is mostly similar to that of Kim et al.,⁷ Morris et al.,¹³ Lippert et al.,⁸ and Zuhail Ozgur et al.⁹ This knowledge could be applied to prevent complications caused by either endovascular therapy (e.g. percutaneous balloon angioplasty and stenting)

TABLE 2. Frequency of Popliteal Arterial Variations

Author	Source	Extremities Examined	IB (modified)		IC (modified)		IID (modified)			New-1 (%)	New-2 (%)
			IA (%)	(%)	(%)	(%)	IIA1 (%)	IIA2 (%)	IIB (%)		
Morris, 1961	Angiography	246	88.6	1.2	2.9	3.6	-	0.8	-	-	-
Bardsley, 1970	Angiography	235	92.8	-	0.4	4.2	-	1.7	-	-	-
Mauro, 1988	Angiography	343	88	1.2	4.1	2.3	-	0.9	-	-	-
Kim, Orron, 1989	Angiography	605	92.6	1.2	2	3	0.7	0.8	<0.2	-	-
Quain, 1844	Dissection	258	90.3	6.6	2.3	0.8	-	-	-	-	-
Adachi, 1928	Dissection	770	96	0.5	0.8	0.9	1	0.8	-	-	-
Trotter, 1940	Dissection	1168	93.4	1.3	0.5	1.5	2.4	1.4	-	-	-
Keen, 1961	Dissection	280	90.7	0.4	4.3	3.6	0.4	1.1	-	-	-
Lippert, 1985	Dissection	-	90	1	4	3	1	1	-	-	-
Zuhail Ozgur, 2009	Dissection	40	90	-	2.5	5	-	2.5	-	-	-
Siriraj	Dissection	230	88.7	0.4	4.8	0.9	1.3	0.9	-	0.9	2.2

or surgical revascularization such as a femorodistal bypass graft.⁷ Kim et al.,⁷ Morris et al.,¹⁵ Bardsley et al.,¹⁶ Lippert et al.,⁸ Adachi et al.,¹⁸ Mauro et al.,¹⁹ Quain et al.,²⁰ Trotter et al.,²¹ Keen et al.,²² and Zuhail Ozgur et al.,⁹ determined the normal branching pattern of the PA at 92.6%, 88.6%, 92.8%, 90%, 96%, 88%, 90.3%, 93.4%, 90.7% and 90% respectively (Table 2). Similar to their studies, this most common pattern was observed in our study 88.7% up in addition to which this normal branching pattern is the most common finding regardless of race and gender. The PA posteriorly divides at the inferior border of the PM by giving off the ATA, which courses laterally toward the fibula before anteriorly running down the calf to terminate as the dorsalis pedis artery. The TPT terminates at the PRA origin. The PTA runs down the posterior calf and terminates at the level of the calcaneus by bifurcating into the medial and lateral tarsal arteries.⁷ The pattern new-1 was found in two legs (0.9%) (Table 1). This pattern is absent in literature. The PA posteriorly divides to the inferior border of the PM by giving off the ATA and the PRA. The ATA, courses laterally toward the fibula before running down the calf to terminate as the dorsalis pedis artery. This pattern shows no PTA. The PTA was replaced by PRA. The PRA runs down the posterior calf and terminates at the level of the calcaneus by bifurcating into the medial and lateral tarsal arteries (Fig 3). This variant has never been previously reported. The pattern new-2 was found approximately 2.2% in this study (Table 1). Although this pattern is classified as a new type according to Kim's classification, this pattern is similar to pattern III-C; hypoplastic-aplastic PTA and ATA of Kim et al.,⁷ but differs because the ATA communicates with the PRA (Fig 3). Jiji PJ et al.,²³ reported a rare variation of PTA that was similar to this study. In the study of Jiji PJ et al.,²³ the PTA was found and terminated by supplying soleus muscle and the PRA was enlarged and supplying the posterior crural region. This explanation was similar to our finding in pattern new-2. However the PRA in Jiji's study was enlarged and only continued at the lateral plantar artery supplying the sole. In our study this artery had a different pattern from Jiji, because it not only terminated into the lateral plantar artery, but also terminated as the dorsalis pedis artery at the dorsum of the foot by communicating between the ATA and the PRA. This was absent from the few patterns reported in literature. The PA posteriorly divides to the inferior border of the PM by giving off the ATA, which courses laterally toward the fibula before running down the calf to communicate with the lateral plantar artery. The short TPT terminates to the PTA and the PRA. The PTA is smaller than the PRA and tapers distally. At the ankle, the dorsalis pedis artery is formed by communicating between the ATA and the PRA. The new pattern is helpful in patients undergoing fibula free flap transfer to prevent a potential complication when the suitable side is chosen. The results of this study demonstrate that there are 2 new patterns in Thais and pattern I-A is mostly found (88.7%). All variations of

patterns did not show statistically significant differences between genders and sides in both groups.

ACKNOWLEDGMENTS

The authors are grateful to the Department of Anatomy, Faculty of Medicine Siriraj Hospital, Mahidol University and Department of Anatomy, Faculty of Science, Mahidol University.

REFERENCES

1. Kishman L, Malin D, Nerone V, Siesel K. Clinical Implications of Peroneal Artery Variation. *Foot Ankle Spec.* 2009 Jun;2(3):135-9.
2. Anne M. R. Agur, Arthur F. Dalley. *Grant's Atlas of Anatomy Twelfth Edition.* Lippincott Williams and Wilkins; 2008; 12: 393-405.
3. Frykberg ER. Popliteal vascular injuries. *Surg Clin North Am.* 2002 Feb; 82(1):67-89.
4. Ellen Casey, Paul H. Lento, Joseph M. Ihm, Heron Rodriguez. *Vascular Injuries in the Lower Limb of Athletes. Nerve and Vascular Injuries in Sports Medicine;* 2009. p. 183-98.
5. Miller HH, Wech CS. Quantitative studies on the factor in arterial injuries. *Ann Surg.* 1949 Sep;130(3):428-38.
6. Jones S, Journeaux SF. Pure hyperextension of the knee causing popliteal artery injury. *Injury.* 1996 Jun;27(5):355-6.
7. Kim D, Orron DE, Skillman JJ. Surgical Significance of Popliteal Arterial Variants. A Unified Angiographic Classification. *Ann Surg.* 1989 Dec; 210(6):776-81.
8. Lippert H, Pabst R. *Arterial variations in man: Classification and frequency.* JF Bergman Verlag, Munich; 1985. 61 p.
9. Ozgur Z, Ucerler H, Aktan Ikiz ZA, Asli Aktan Ikiz. Branching patterns of the popliteal artery and its clinical importance. *Surg Radiol Anat.* 2009 Jun;31(5):357-62.
10. Keser S, Savranlar A, Bayar A, Ulukent SC, Ozer T, Tuncay I. Anatomic localization of the popliteal artery at the level of the knee joint: a magnetic resonance imaging study. *Arthroscopy.* 2006 Jun;22(6):656-9.
11. Klecker RJ, Winalski CS, Aliabadi P, Minas T. The aberrant anterior tibial artery: magnetic resonance appearance, prevalence, and surgical implications. *Am J Sports Med.* 2008 Apr;36(4):720-7.
12. Dar AM, Ahanger AG, Wani RA, Bhat MA, Lone GN, Shah SH. Popliteal artery injuries: the Kashmir experience. *J Trauma.* 2003 Aug;55(2):362-5.
13. Tindall AJ, Shetty AA, James KD, Middleton A, Fernando KW. Prevalence and surgical significance of a high-origin anterior tibial artery. *J Orthop Surg (Hong Kong).* 2006 Apr;14(1):13-6.
14. Wain RA, Hines G. A contemporary review of popliteal artery aneurysms. *Cardiol Rev.* 2007 Mar-Apr;15(2):102-7.
15. Morris GC Jr, Beall AC Jr, Berry WB, Feste J, DE Bakey ME. Anatomical studies of the distal popliteal artery and its branches. *Surg Forum.* 1960; 10:498-502.
16. Bardsley JL, Staple TW. Variations in branching of the popliteal artery. *Radiology.* 1970 Mar;94(3):581-7.
17. Senior HD. The development of the arteries of the human lower extremity. *Am J Anat.* 1919;25:55-94.
18. Adachi B. *Das arteriensystem der Japaner, Band II.* Verlag der Kaiserlich, Kyoto; 1928. 151 p.
19. Mauro MA, Jacques PF, Moore M. The popliteal artery and its branches: embryological basis of normal and variant anatomy. *AJR Am J Roentgenol.* 1988 Feb;150(2):435-7.
20. Quain R. *The anatomy of the arteries of the human body.* London: Taylor & Walter; 1844. p. 530-43.
21. Trotter M. The level of termination of the popliteal artery in the white and the negro. *Am J Phys Anthropol.* 1940;27:109-18.
22. Keen JA. A study of the arterial variations in the limbs with special reference to symmetry of vascular patterns. *Am J Anat.* 1961 May;108:245-61.
23. Jiji PJ, et al. Hypoplastic posterior tibial artery and the enlarged peroneal artery supplying the posterior crural region: a rare variation. *Journal Vascular Brasileiro, Porto Alegre, Sept.* 2008;7(3).