

PREVALENCE AND ANATOMICAL PATTERN OF THE MEDIAN ARTERY AMONG ADULT BLACK KENYANS

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ABSTRACT

Knowledge of the anatomy of median arteries is important in the diagnosis and management of carpal tunnel and pronator teres syndromes, reconstructive surgery in the forearm, minimizing inadvertent vascular injury as well as in limiting operative complications due to unexpected bleeding. The anatomical pattern displays ethnic differences but there are few studies on black Africans. This study therefore sought to describe the anatomy of median arteries in an adult black Kenyan population. A total of sixty two (62) upper limbs from thirty one (31) formalin-fixed cadavers were studied at the Department of Human Anatomy, University of Nairobi, Kenya. The prevalence, origin, types, relationship with median nerves and termination were determined. Median arteries were observed in 37 (59.7%) cases. Of these, the palmar type comprised 12 (32.4%) and antebrachial type 25 (67.6%) cases. It occurred bilaterally in 14 (45.2%) cases. The most common origin was the common interosseous artery (21; 56.8%) followed by anterior interosseous (13; 35.1%) and ulnar 3 (8.1%) arteries. The artery pierced the median nerve in 7 (18.9%) cases. The palmar type terminated by uniting with the ulnar artery to form a median-ulnar type of superficial palmar arterial arch in 8 (21.6%) cases and directly gave rise to the first, second and third common digital arteries in 4 (10.8%). In conclusion, the median artery occurs in nearly 60% of the population, much higher than in prevailing literature reports. Prevalence of the palmar type of median arteries and that of median arteries piercing median nerves are also higher than in other populations. Accordingly, presence of median artery and consequently other vascular and median nerve variations should be considered in the differential diagnosis of forearm entrapment neuropathies and due caution taken during forearm surgical procedures. We recommend preoperative ultrasound evaluation of the forearm and hand vascular system.

Keywords: Median artery, origin, prevalence, median nerve, Kenyan

INTRODUCTION

Median artery is a transitory vessel that represents the embryonic arterial axis of the forearm. It usually regresses into a thin vessel that supplies the median nerve, to be replaced by the ulnar and the radial arteries during the eight week of gestation (Eid et al., 2011; Agarwal et al., 2013). It may, however, persist in adults in one of two patterns namely, palmar or antebrachial. The palmar type represents the

embryonic pattern, and is therefore sometimes referred to as the persistent median artery (PMA). The PMAs are usually long, prominent vessels which extend to the palmar aspect of the hand. The antebrachial type, on the other hand, represent partial regression of the axial artery, are usually short, narrow and limited to the forearm (Rodriguez-Niedenfuhr et al., 1999; Aragao, 2017). Median arteries are clinically

important for several reasons: first, because of their superficial location, they are vulnerable to injury; secondly, they may cause compression neuropathies like carpal tunnel syndrome; thirdly, they are associated with other variations of upper limb arteries and median nerve (Gassner et al., 2002; Natsis et al., 2009; Salter et al., 2011; Raviprassan and Dakshayani, 2014; Agarwal et al., 2014); fourthly, their injury may cause ischemia of the hand and forearm when they constitute the major source of blood supply (Tsuruo et al., 2006; Agarwal et al., 2014; Patnaik and Paul, 2016); fifthly, they may be used as a graft artery (Arifoglu et al., 2008; Agarwal et al., 2013; Kandori et al., 2015); and finally during surgical procedures in the forearm or the wrist and median nerve block, their inadvertent injury may cause unexpected troublesome bleeding (Stimpson and Gupta, 2012). Accordingly, accurate knowledge of their

anatomical pattern is critical in understanding upper limb vascularization and mitigating the potential surgical risks.

The anatomical pattern of the median artery shows ethnic and geographical variations (Shrivastava and Pande, 1990; George and Henneberg, 1996; Kopuz et al., 1997; Kandori et al., 2015). Consequently, population specific data are critical in guiding surgery. Pertinently, reconstructive flap surgery of the fore arm and hand are gaining prominence in Kenya (Nangole et al., 2015). There are, however, only a few studies from Africa (Henneberg and George, 1992; George and Henneberg, 1996) and none from the East African region. Consequently, little is known about this artery in the black African populations. The aim of this study is therefore to determine the anatomical pattern of the median arteries among black Kenyans.

MATERIALS AND METHODS

This was a descriptive cadaveric study conducted at the Department of Human Anatomy University of Nairobi, Kenya. A total of sixty two (62) upper limbs from thirty-one (31) formalin fixed cadavers of adult black Kenyans aged 25 – 72 years (24 males, 7 females) were studied. The limbs were categorized into those of males and those of females, then right and left. Two longitudinal skin incisions were made. A lateral one running from the coracoid process to the base of the thumb and a medial one from the axilla to the base of the digiti minimi. The anterior skin flap and fascia were removed and the cubital fossa, the flexor compartment of the forearm and the palmar aspect of the hand exposed. Flexor digitorum superficialis muscle was detached from its origin, and reflected distally to expose the arteries of the forearm. Careful dissection of the brachial artery and its terminal branches was done.

Median artery was identified as that artery other than the ulnar, radial and interosseus arteries found in the middle of the flexor compartment. The artery was defined as antebrachial if it ended at or proximal to the wrist and palmar if it transversed the carpal tunnel to enter the palm. For the palmar types, the carpal tunnel was opened carefully and the artery followed to its point of termination on the palmar aspect of the hand. The arteries with which it anastomosed were examined.

Prevalence, origin, type, course in relation to median nerve and termination were determined. The data obtained were entered into SPSS software (Version 21.0, Chicago, Illinois) for analysis. The Paired Student's t-test was used to compare the above variables between the right and left sides. A p -value of <0.05 was considered significant at a 95% confidence interval.

RESULTS

Arteries of the forearm and hand were visible in all sixty two upper limbs. Observations were made for all the variables in question namely the prevalence, origin, type, course in relation to the median nerve and pattern of termination.

Prevalence

Median arteries were observed in 37 (59.7%) of the 62 limbs. In 14 (37.8%) they were bilateral (Table 1). Twenty were on the right, while 17 were on the left. Out of the 37 median arteries, 25 (40.32%) were antebrachial while 12 (19.4%) were palmar. In the antebrachial variety, the arteries were slender, tapered off and terminated in the distal third of the forearm

[Fig 1A].The palmer definite reasonable arteries which ran the full extent of the forearm, traversed the carpal tunnel and entered the hand. There were no cases where the artery was anterior to the flexor retinaculum (Fig 1B).

Origin

The median arteries originated from the common interosseous artery in 21 (56.8%) cases [Fig 2A], anterior interosseous artery in 13 (35.1%) cases [Fig 2B] and ulnar artery in 3 (8.1%) cases [Fig 2C].

Table 1: Side differences in the pattern of median arteries among adult black Kenyans

| | | Right side n(%) | Left side n(%) | p-value | Total n(%) |
|---------------------------|------------------------------|----------------------------|---------------------------|----------------|-----------------------|
| Presence | | n=20 (32.2%) | n=17 (27.5%) | 0.476 | n=37 (59.7%) |
| | Palmar | n=8 (12.9%) | n=4 (6.5%) | | n=12 (19.4%) |
| | Antebrachial | n=12 (19.3%) | n=13 (21.0%) | | n=25 (40.3%) |
| | Common interosseous artery | n=9 (24.3%) | n=12 (32.4%) | | n=21 (56.8%) |
| | Anterior interosseous artery | n=8 (21.6%) | n=5 (13.5%) | | n=13 (35.1%) |
| | Ulnar artery | n=3 (8.1%) | n=0 (0%) | | n=3 (8.1%) |
| Piercing the median nerve | | n=4 (10.8%) | n=3 (8.1%) | 0.684 | n=7 (18.9%) |

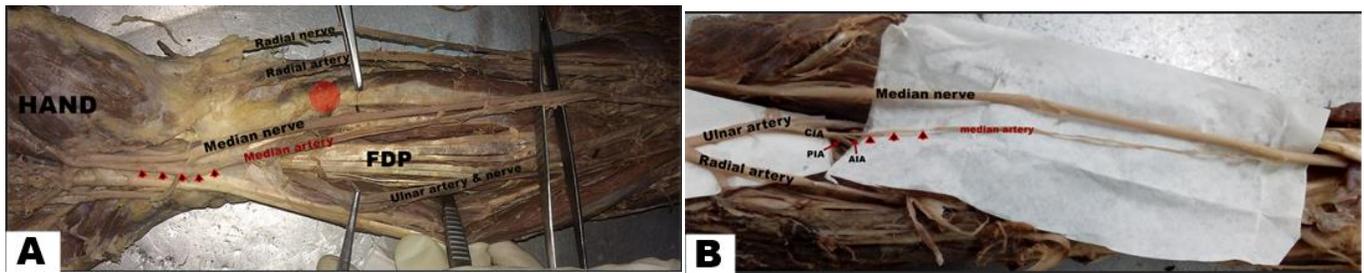


Figure 1: Types of Median artery. A: Palmar type of median artery (red arrows). Note the median artery extending to the palmar aspect of the hand, accompanied by the median nerve. **FDP**=Flexor digitorum profundus. B: Antebrachial type of the median artery. Note that it is short, thin and limited only to the forearm. **CIA**=common interosseous artery, **AIA**= Anterior interosseous artery; **PIA** = Posterior Interosseus Artery.

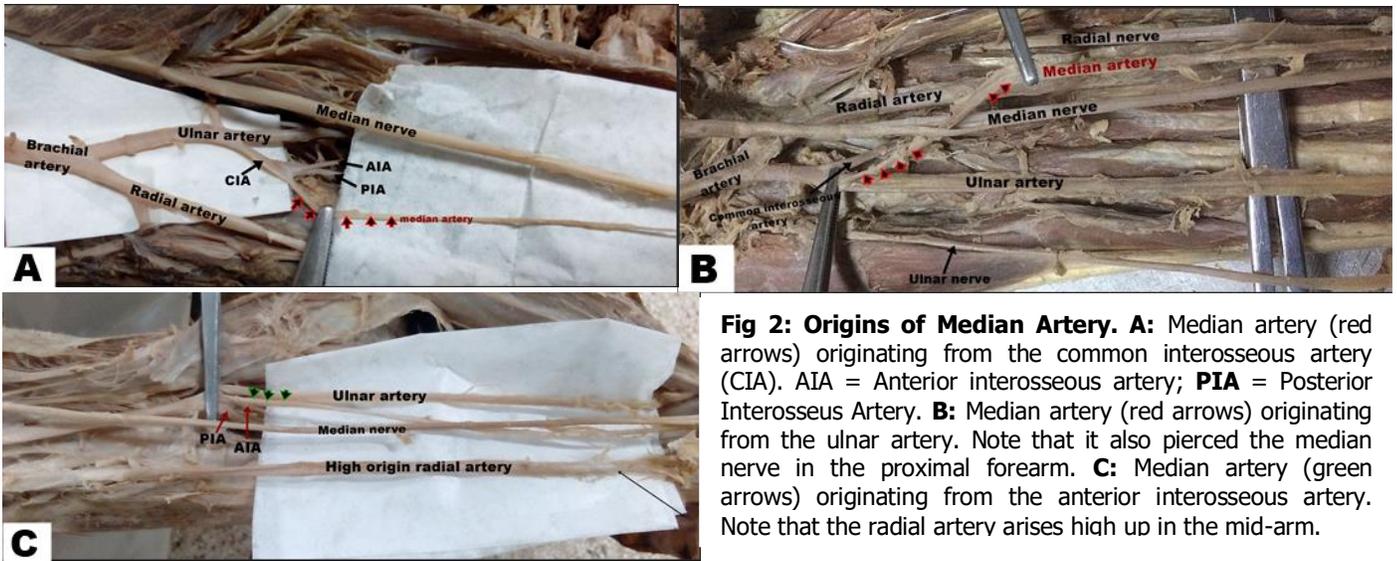


Fig 2: Origins of Median Artery. **A:** Median artery (red arrows) originating from the common interosseous artery (CIA). AIA = Anterior interosseous artery; PIA = Posterior Interosseus Artery. **B:** Median artery (red arrows) originating from the ulnar artery. Note that it also pierced the median nerve in the proximal forearm. **C:** Median artery (green arrows) originating from the anterior interosseous artery. Note that the radial artery arises high up in the mid-arm.

Course in relation to the median nerve

The median artery ran lateral to the median nerve in 12 cases, medial to it in 18 cases and pierced the median nerve in 7 (18.9%) cases. In the latter cases, the arteries originated from the ulnar artery. The piercing occurred in the proximal one third of the forearm (Fig 3A, B).

Pattern of termination

The palmar type united with a superficial branch from the ulnar artery to form a median-

ulnar type of complete superficial palmar arterial arch (SPA) [Fig 4A] in 8 (21.6%) cases. The remaining 4 (10.8%) terminated by giving rise to the first, second and third common digital arteries [Fig 4A,B]. No significant side differences were noted in the presence, type or origin of PMA.

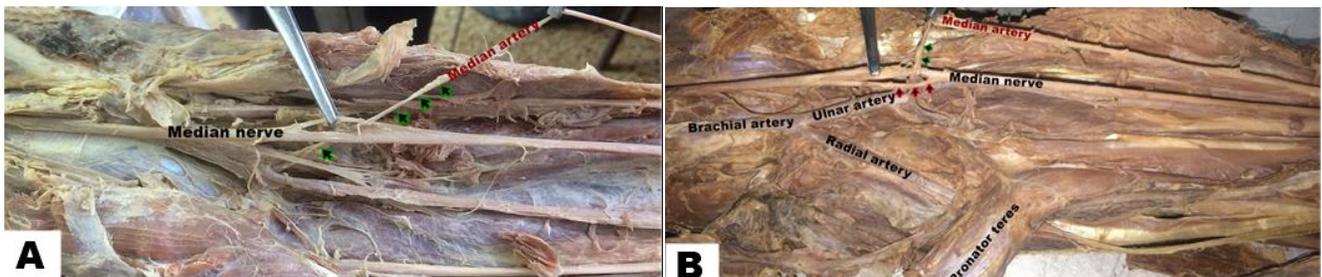


Figure 3A, B: Relationship between the median artery and median nerve. Note the median artery (green arrows) piercing the median nerve in the proximal forearm.

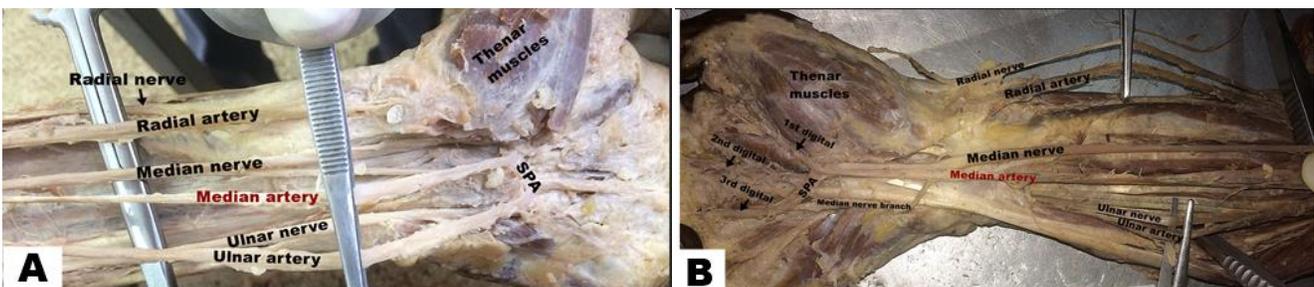


Figure 4: Pattern of termination of the palmar type of median artery. **A:** PMA uniting with the ulnar artery to form a median-ulnar type of a superficial palmar arterial arch (SPA). **B:** PMA giving rise to the 1st, 2nd and 3rd common digital arteries. Note the anastomosis between third digital artery and the ulnar artery.

DISCUSSION

The median artery may constitute an important source of blood and collateral circulation for the forearm and hand (Tsuruo et al., 2006; Agarwal et al., 2014; Patnaik and Paul, 2016). It is important to understand the prevalence, origin, course, relationship with median nerve and pattern of termination in order to avoid inadvertent injury (Nayak et al., 2010; Patnaik and Paul, 2016).

Prevalence

The prevalence of median arteries varies between 1.5 – 60% (Natsis et al., 2009; Aung and Than, 2009; Agarwal et al., 2014; Henry et al., 2015). Observations of the current study reveal a prevalence of 57.9%, which is comparable only to 60% among Malaysians (Aung and Than, 2009), but much higher than in other previous reports [Table 2].

Type

In the present study, the antebrachial and palmer types were observed in 67.6% and 32.4% of all cases respectively. The more

frequent occurrence of the antebrachial type is consistent, with literature reports although lower than the 70 – 100% in contemporary literature (Natsis et al., 2009; Rodriguez – Niederfur, 2009; Potu et al., 2011). A remarkable finding of the current study, however, is the 32.4% prevalence of PMA, comparable to 27.1% among black South Africans but otherwise higher than 4 – 23% in prevailing literature (Shrivastava and Pande, 1990; Henneberg and George, 1992; Aung and Than, 2009; Potu et al., 2011; Bilodi et al., 2014) [Table 2].

These wide variations may be related to differences in definition, denominators or method, but it is also probably related to ethnic and geographical variations. Indeed it has been suggested that the median arteries are more common in black populations (George and Henneberg, 1996). This suggests that surgeons operating in the forearm of this population should beware of this artery to avoid its inadvertent injury.

Table 2: Prevalence of median artery in various populations

| Reference | N | Population | Percent Prevalence |
|----------------------------|-----|----------------|--------------------|
| Agarwal et al., 2014 | 52 | Indian | 11.53 |
| Aung and Than, 2009 | 120 | Malaysian | 60 |
| Chen et al., 2016 | 160 | Chinese | 7.5 |
| Claassen et al., 2008 | 54 | German | 7.4 |
| Eid et al., 2011 | 50 | Japanese | 4 |
| Gassner et al., 2002 | 100 | Austrian | 26 |
| Henneberg and George, 1999 | 96 | South Africans | 27.1 |
| Milligan, 2013 | 223 | American | 19.2 |
| Potu et al., 2011 | 50 | Indian | 8 |
| Current study | 62 | Kenyan | 57.9 |

Table 3: Prevalence of persistent median arteries among different populations

| Author | Population | N | Percent Prevalence |
|----------------------------------|---------------|-----|--------------------|
| Aung and Than, 2009 | Malaysian | 120 | 8.3 |
| Claasen et al., 2008 | German | 54 | 7.4 |
| Henneberg and George, 1992 | South African | 96 | 27.1 |
| Natsis et al., 2009 | Greeks | 72 | 2.78 |
| Patnaik and Paul, 2016 | Indians | 45 | 15.5 |
| Rodriguez-Niedenfuhr et al.,1999 | Spaniards | 120 | 20 |
| Present study | Kenyan | 32 | 32.4 |

This suggests an ethnic difference, in which black Africans have a higher prevalence of PMA. This difference may be attributed to genetic factors, such as variations in the single nucleotide polymorphisms (SNPs) within the gene loci regulating the pattern of upper limb vascularization (Patnaik and Paul, 2016). This calls for more comparative studies among different ethnic communities.

Origin

Origin of MA is important during harvesting of forearm vascular flaps. For instance, the MA may be injured when harvesting ulnar (Lovie et al., 1984) or radial artery (Acarturk et al., 2008) flaps, resulting in ischemia of the hand, especially in cases where the MA constitutes its significant source of blood supply. The median artery is most commonly a branch of the ulnar (Aung and Thang, 2009; Natsis et al., 2009) followed by common interosseus, anterior interosseus, brachial and radial arteries (Varley et al., 2008; Arifoglu et al., 2008; Natsis et al., 2009; Aung and Than, 2009). In the present study, the MA originated from ulnar artery in only 8.1% of cases, instead predominantly arising from the common interosseous artery (CIA). This is concordant with the findings by Hennberg and George (1992), Nayak et al., (2009) and Aragão et al., (2017). It supports

the ascertions that the MA may arise from any artery of the forearm and arm (Rodriguez – Niedenfuhr et al. 1999). The embryological basis for the variability is probably the pattern of development of the arterial supply of the forearm. The arteries develop from a capillary plexus that undergoes differentiation in a distal-proximal fashion (Rodriguez-Niedenfuhr et al.,1999). Due care should therefore be taken during surgical and radiological procedures on the forearm and hand. In view of wide variability, preoperative Doppler Ultrasound evaluation is recommended.

Relationship with the median nerve

The 18.9% incidence of MA piercing the median nerve (MN) in the proximal forearm demonstrated in the current study, though lower than 41% among the Spaniards (Rodriguez-Niedenfuhr et al., (1999), is higher than 2% among the Japanese (Eid et al., 2011) and 1.6% among the Indians (Singla et al., 2012). This wide range could be attributed to methodological differences. For example, whereas the present study used total number of MA observed as the denominator in the calculation of incidences of MN perforated by MA, Rodriguez-Niedenfuhr et al., (1999) used only the total number of palmar type of MA as the denominator. This neurovascular

relationship is considered to be a phylogenetic remnant as it is commonly observed in some lower primates where it is viewed as an adaptation for extreme muscular movements (Eid et al., 2011). In case of human beings, the MA may compress the nerve fibers immediately surrounding them, resulting in carpal tunnel and pronator teres syndromes (Tsagarakis et al., 2004; Singla et al., 2012; Stavros et al., 2016; Patnaik and Paul, 2016). PMA should therefore be taken into account when assessing entrapment neuropathies involving the median nerve.

Termination

The PMA terminated in the hand by either uniting with a branch of the ulnar artery to form a median-ulnar type of superficial palmar arterial arch in 8 (66.7%) of cases. This is higher than 4 – 60% in contemporary literature (Rodriguez-niedenfuhr et al., 1999; Bilodi et al., 2001; Natsis et al., 2009; Nayak et al., 2010; Raviprassana and Dakshayani, 2014). In such,

CONFLICT OF INTEREST: There is no conflict of interest in this study

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or where it gives rise to digital branches, its damage may compromise blood supply to the digits (Nejad et al., 2016; Bijannejad et al., 2016). Accordingly, caution should be taken during various surgical procedures on the forearm such as harvesting of vascular flaps and carpal tunnel decompression to avoid iatrogenic injury to the PMA and subsequent inadvertent ischemia of hand muscles.

In conclusion, the median artery is present in nearly 60% of the population, much higher than in prevailing literature reports. Prevalence of the palmar type of median arteries and that of median arteries piercing median nerves is also higher than in other populations. Accordingly, presence of median artery and consequently other vascular and median nerve variations should be considered in the differential diagnosis of forearm entrapment neuropathies and due caution taken during forearm surgical procedures. We recommend preoperative ultrasound evaluation of the forearm and hand vascular system.

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