

Research article – Basic and applied anatomy

## Persistent median artery of the forearm and palm: a cadaver study into its origin, course, fate and clinical significance

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### Abstract

The median artery is the axis artery of forearm till the 8<sup>th</sup> week of gestation and thereafter normally regresses, only its proximal part remaining patent as the companion artery of the median nerve in adults. A large, well developed persistent median artery extended to the palm and contributed to its vascular supply in 6 out of 100 upper limbs dissected. Dissection was used to demonstrate the persistent median arteries from their origin to termination. The persistent median artery originated from the ulnar artery in the cubital fossa. It pierced the median nerve, descended anterior to the nerve in a common sheath and passed deep to the flexor retinaculum. An accessory head of *flexor pollicis longus*, which is a usual finding associated with the persistent median artery, was seen in one forearm. The superficial palmar arch was not seen in any specimen with persistent median artery. In all the specimens with persistent median artery, the lateral half of the palm and lateral 2½ digits were supplied by it, whereas the medial half of palm and the medial 2½ digits were supplied by the ulnar artery. The persistent median artery may contribute to median nerve compression neuropathy. The variations in the vascular supply of hand have clinical implications.

### Key words

Persistent median artery, Carpal tunnel syndrome

### Introduction

The median artery acts as the axis artery till the 8<sup>th</sup> week of gestation and is then replaced by the ulnar artery and finally the radial artery (Nayak et al., 2010; Eid et al., 2011). The median artery degenerates and only its proximal part remains patent thereafter, accompanying the median nerve as the companion artery (Rodriguez–Niedenfuhr et al., 1999; Varley et al., 2008; Eid et al., 2011). Any departure from the normal pattern of differentiation results in arterial variations (Rodriguez–Niedenfuhr et al., 2001). The median artery in adults may have either (1) an antebrachial pattern, as a short and slender vessel that doesn't reach the palm (Rodriguez–Niedenfuhr et al., 1999; Varley et al., 2008; Nayak et al., 2010; Eid et al., 2011), or (2) a palmar pattern, as a long, large vessel that terminates in the superficial palmar arch or as 1<sup>st</sup> or 2<sup>nd</sup> or both 1<sup>st</sup> and 2<sup>nd</sup> common palmar digital arteries (Rodriguez–Niedenfuhr et al., 1999; Nayak et al., 2010). It may persist in adults, providing most of the blood supply

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to the palm (Coleman and Anson, 1961; Schuenke et al., 2010) and the persistence of this embryonic form is called Persistent Median Artery (PMA) (Natsis et al., 2009).

A PMA may originate from any of the forearm arteries (Rodriguez–Niedenfuhr et al., 1999; Acarturk et al., 2008; Varley et al., 2008; Eid et al., 2011) or even the axillary or the brachial artery (Srivastava and Pande, 1990). The PMA runs with the median nerve and in certain cases pierces it (Rodriguez–Niedenfuhr et al., 1999; Nayak et al., 2010). Cases of PMA piercing the anterior interosseous nerve in the forearm have been reported (Proudman and Menz, 1992). Thus, it may contribute to nerve entrapment and compressive neuropathies.

The aim of the study is to add to our existing knowledge about the vascular pattern of the hand since much reconstructive and reimplantation surgery is performed today. The present study deals with the origin, course and termination of the PMA and its topographical relations with the median nerve, anterior interosseous nerve and Gantzer's muscle.

## Materials and methods

The study was conducted in 50 embalmed cadavers (100 upper limbs), with a sex distribution of 8 female and 42 male bodies, ranging from 27 to 80 years of age.

The upper limbs were studied during routine dissection for undergraduate medical teaching. The upper limbs with the PMA were dissected from origin to termination of the same artery.

## Results

### Forearm

In the present study, the brachial artery (H in Fig. 1) in the cubital fossa divided into the ulnar (C in Fig. 1) and the radial artery (B in Fig. 1). The ulnar artery after descending for about 5-7 cm in the cubital fossa divided into three branches. (1) The first branch was seen to run medially towards the median nerve (A in Fig. 1) and pierced it (F in Fig. 1) under the cover of the *pronator teres* (I in Fig. 3). This branch supplied the median nerve in the forearm and continued distally with its *venae comitantes*, anterior to the median nerve in a common sheath (G in Fig. 1), between the deep and the superficial forearm flexors till the wrist. This branch was interpreted as a PMA (E in Fig. 1). (2) The second branch, 4-5 cm distal to its origin, divided again into two branches: one accompanied the anterior interosseous nerve and was interpreted as the anterior interosseous artery and the other entered the extensor compartment above the interosseous membrane and was interpreted as the posterior interosseous artery. So, the second branch was interpreted as the common interosseous artery (D in Fig. 1). (3) The third branch continued with the ulnar nerve (D in Fig. 2) till the wrist and was most likely the continuation of the ulnar artery (E in Fig. 2).

A PMA was observed in 3 cadavers, all from males and in all cases bilaterally. In one forearm, an accessory head of flexor pollicis longus (Gantzer's muscle) was seen deep to the common sheath, containing the PMA and the median nerve.

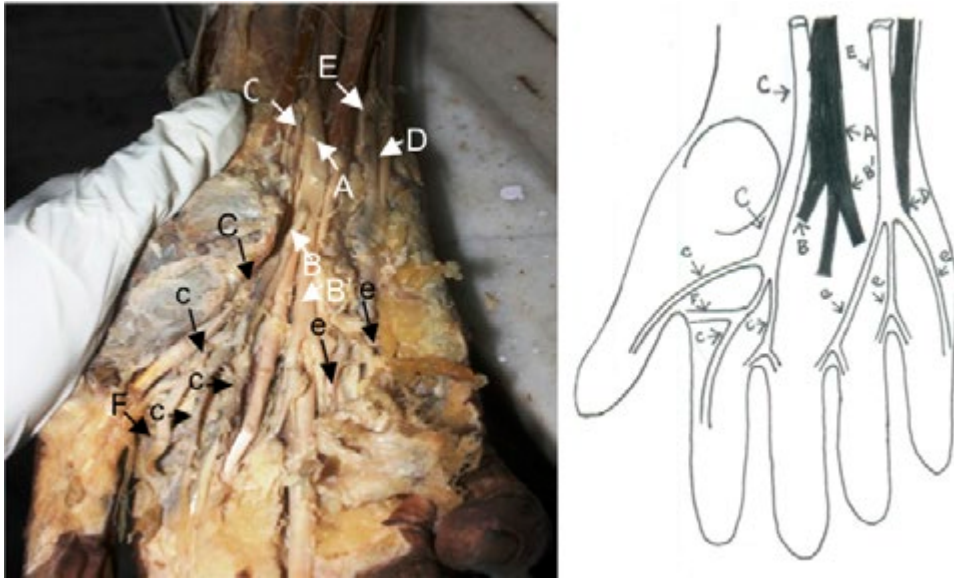


**Figure 1** – Right cubital fossa. A: Median nerve, B: Radial artery, C: Ulnar artery, D: Common interosseous artery, E: Persistent median artery (PMA), F: Piercing of median nerve by PMA, G: Median nerve and PMA in a common sheath, H: Brachial artery, I: Reflected tendon of pronator teres.

### Palm and digits

All cases with PMA were marked by absence of the superficial palmar arch. At the distal border of the flexor retinaculum, the PMA (C in Fig. 2, A in Fig. 3) diverted to the lateral side of the median nerve (A in Fig. 2, C in Fig. 3) and supplied the lateral half of the palm and the lateral two and half digits by dividing into three branches: (1) a branch to the medial side of the thumb, (2) a branch to the radial side of the index finger, and (3) a common palmar digital artery to the second web space. In one hand, the branch to the medial side of the thumb and to the radial side of the index finger originated by a common stem from the PMA (A and a in Fig. 3) in the proximal part of the palm. In another hand, the radial artery (F in Fig. 2) anastomosed with the branch of the PMA to the radial side of the index finger in the first web space.

In the hands with the PMA, the medial half of the palm and the medial two and half digits were supplied by the ulnar artery (E in Fig. 2, B in Fig. 3) through three branches: (1) a proper palmar digital artery to the medial side of the little finger, (2) a common palmar digital artery to the third web space, and (3) a common palmar digital artery to the fourth web space. In all specimens, there was no anastomosis between the PMA and the ulnar artery in the palm.

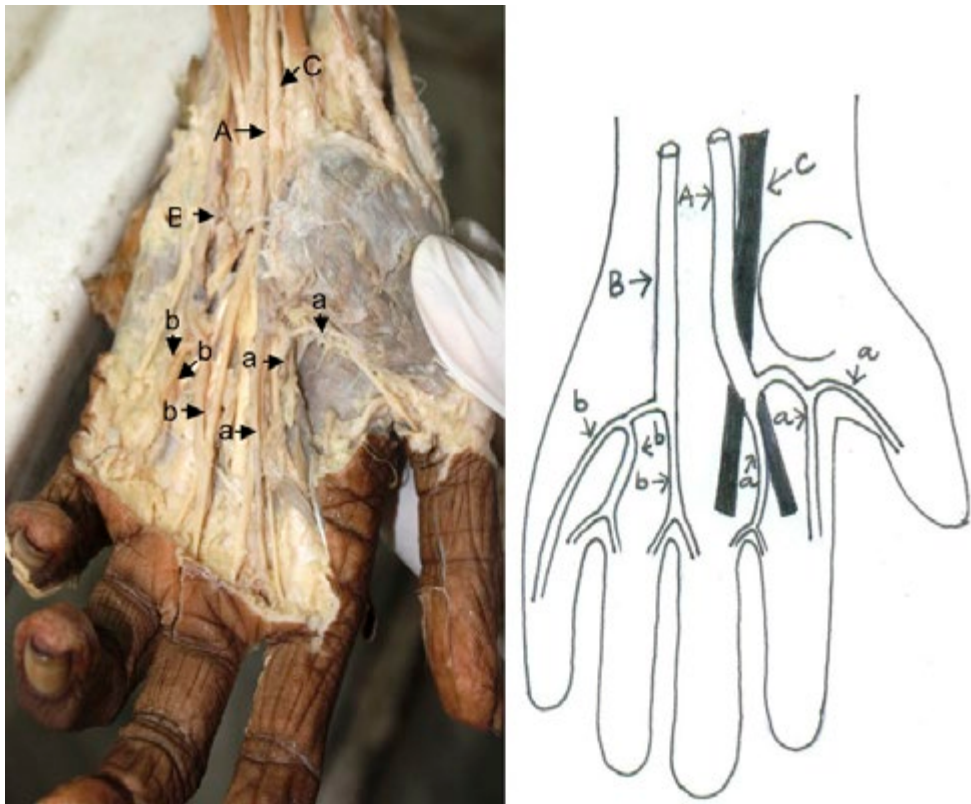


**Figure 2** – Vascular territory of PMA in right palm. A: Median nerve; B, B': Lateral and medial branches of median nerve; C, c: PMA and its branches supplying lateral 2½ digits; D: Ulnar nerve; E, e: Ulnar artery and its branches supplying medial 2½ digits; F: Radial artery.

**Discussion**

In this study, a PMA was seen in 6% upper limbs, but existing literature puts it at 1.5-27.4% upper limbs (Henneberg and George, 1992; Rodriguez-Niedenfuhr et al., 1999; Nayak et al., 2010; Eid et al., 2011). In Indian population, incidence of PMA ranges from 1.5-15.8% upperlimbs (Srivastava and Pande, 1990; D’Costa et al., 2006; Nayak et al., 2010). The PMA can occur isolate or with other variations of the brachio-antebrachial arterial pattern (Rodriguez-Baeza et al., 1995). There are ethnic variations, the PMA being more common in black South Africans (Acarturk et al., 2008), though other studies based on African population consider it to be a regional rather than an ethnic trend (Henneberg and George, 1992). Lack of consensus regarding nomenclature of anomalous arteries of the forearm (Varley et al., 2008), different methods of calculations, like using hands (Rodriguez-Niedenfuhr et al., 1999) or cases (Gassner et al., 2002) as denominator, or even less exacting techniques of observation may contribute to the wide range of incidence (Henneberg and George, 1992).

In this study, PMA was seen in the male cadavers but existing literature has reported no significant difference between the sexes (Henneberg and George, 1992; Rodriguez-Niedenfuhr et al., 1999). The present results may depend simply on the fact that 42 over 50 cadavers in the study were male. Here, a PMA was observed on both sides, in line with some existing studies (Henneberg and George, 1992; Srivastava and Pande, 1990; Rodriguez-Niedenfuhr et al., 1999); however, one study stated that a PMA was twice likely to be found on the left side than the right (D’Costa et



**Figure 3** – Vascular territory of PMA in left palm. A, a: PMA and its branches, supplying lateral 2½ digits; B, b: Ulnar artery and its branches, supplying medial 2½ digits; C: Median nerve.

al., 2006) and in the literature it has been described mostly unilateral (Rodriguez–Niedenfuhr et al., 1999; D’Costa et al., 2006), or there was no marked tendency for PMA to occur unilaterally or bilaterally (Henneberg and George, 1992).

In the present study, a PMA originated from the ulnar artery. A PMA may arise from any of the brachio-antebrachial arterial trunks: (a) the ulnar artery (Srivastava and Pande, 1990; Henneberg and George, 1992; Rodriguez–Niedenfuhr et al., 1999; D’Costa et al., 2006; Nayak et al., 2010; Agarwal et al., 2011; Eid et al., 2011); (b) the common interosseous artery (Gainor and Jeffries, 1987; Henneberg and George, 1992; Proudman and Menz, 1992; Rodriguez–Niedenfuhr et al., 1999; D’Costa et al., 2006; Nayak et al., 2010; Eid et al., 2011); (c) the anterior interosseous artery (Gainor and Jeffries, 1987; Henneberg and George, 1992; Rodriguez–Niedenfuhr et al., 1999; D’Costa et al., 2006; Nayak et al., 2010; Eid et al., 2011); (d) the caudal angle between the ulnar artery and the common interosseous artery (Rodriguez–Niedenfuhr et al., 1999); (e) the radial arterial system in 0.1% specimens (Acarturk et al., 2008), the reconstructive surgeon should have knowledge about this rare anomaly when harvesting radial forearm flap (Acarturk et al., 2008; Varley et al., 2008); (f) the brachial

artery (Natsis et al., 2009; Nayak et al., 2010; Eid et al., 2011); (g) the axillary artery (Srivastava and Pande, 1990); (h) the anterior ulnar recurrent artery (Gainor and Jeffries, 1987). The study by D'Costa et al. (2006) showed an interesting feature: right-sided PMAs originated from the ulnar artery, so were more proximal than left-sided PMAs which originated from the common interosseous artery or the anterior interosseous artery.

In this study, the PMA originated in the cubital fossa and this was coherent with existing literature (Barfred et al., 1985; Rodriguez-Baeza et al., 1995); however one study (Henneberg and George, 1992) reported a PMA originated several centimetres below the cubital fossa and another (Acarturk et al., 2008) reported that a PMA originated from radial artery at mid-forearm level. In the present study, PMA pierced the median nerve and continued distally with the nerve in a common sheath deep to the superficial forearm flexors till the wrist, as reported by most authors.

In our study, PMA was anterior to the median nerve in the carpal tunnel, which is substantiated by existing literature. A PMA may also lie medial to the median nerve in the carpal tunnel (Nayak et al., 2010; Eid et al., 2011). Thus a PMA, even if disease-free, can contribute to carpal tunnel syndrome (Luyendijk, 1986; Dickinson and Kleinert, 1991; Rodriguez-Niedenfuhr et al., 1999).

This study showed the absence of superficial palmar arch in association with PMA. Absent or incomplete superficial palmar arch with PMA has been reported in 65% cases. But in upper limbs having usual distribution of radial and ulnar arteries and without a PMA, the absence of the superficial palmar arch is seen only in 10-20% cases (Varley et al., 2008). Existing studies state that PMA may join the superficial palmar arch in 3 – 35% cases (Coleman and Anson, 1961; Al-Turk and Metcalf, 1984; Natsis et al., 2009; Nayak et al., 2010; Eid et al., 2011; Rodriguez-Niedenfuhr et al., 1999). The wide variation in incidence may be due to the fact that the anastomotic branch between the PMA and the ulnar artery is very thin and may get damaged during dissection (Rodriguez-Niedenfuhr et al., 1999).

In this study, the PMA gave off the 2<sup>nd</sup> common palmar digital artery apart from branches to the medial side of the thumb and the radial side of the index finger. According to existing literature, when PMA doesn't join the superficial palmar arch it gives rise to the first or second or both the first and second common palmar digital arteries (Coleman and Anson, 1961; Al-Turk and Metcalf, 1984; Henneberg and George, 1992; Rodriguez-Niedenfuhr et al., 1999; Acarturk et al., 2008; Nayak et al., 2010). In our study, there was no anastomosis between the PMA and the ulnar artery and this is significant to plastic surgeons and neurosurgeons as inadvertent damage to the PMA may cause hand ischemia.

In this study, the PMA pierced the median nerve in all specimens. Others put the frequency of this condition at 7.1-41% (Srivastava and Pande, 1990; Rodriguez-Baeza et al., 1995; Nayak et al., 2010; Eid et al., 2011). There may be double piercing of the median nerve which might cause pronator syndrome (Gainor and Jeffries, 1987; Eid et al., 2011).

Persistent median artery is more likely to be associated with other abnormalities of the median nerve like high division (Khashaba, 2002; Nayak et al., 2010). An abnormal communicating branch from the musculo-cutaneous nerve to median nerve that winds around the PMA in a common sheath with the median nerve in the forearm has been reported (Agarwal et al., 2011). Gassner (2002) observed that 63% of

hands with a median artery had a variation in the anatomy of the median nerve.

In this study, PMA was anterior to the anterior interosseous nerve in all specimens. Existing literature reveals that PMA is anterior to the anterior interosseous nerve in 67% cases, posterior to it in 25% cases and pierces it in the rest of cases (Rodriguez–Niedenfuhr et al., 1999). This may contribute to Anterior Interosseous Nerve Syndrome (Proudman and Menz, 1992; Krishnamoorthy et al., 1998). There is a report of the PMA piercing both the median nerve and the medial branch of anterior interosseous nerve (Rodriguez–Niedenfuhr et al., 1999).

In one forearm in the present study, a PMA was anterior to an accessory head of *flexor pollicis longus* (Gantzer's muscle). Similar finding has been reported earlier (Proudman and Menz, 1992; Rodriguez–Niedenfuhr et al., 1999; Eid et al., 2011).

Persistent median artery, though an infrequent anomaly, when present is an important vascular source for the hand as it is usually associated with an incomplete or absent superficial palmar arch. Thus, inadvertent damage of the PMA may be a cause for vascular insufficiency of the hand. The PMA itself or complications thereof may contribute to Carpal Tunnel Syndrome. Knowledge about the origin, course and relations of PMA and its contribution to the blood supply of the hand will help the surgeons in the fields of vascular and reimplantation surgery. Thus, the study of PMA is both of academic interest and clinical utility. Further studies are needed to correlate the presence of PMA with the existence of other neurovascular variations of the upper limb.

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