Handedness may be related to variations in palmar arterial arches in humans

Aniruddha Sarkar[1], MBBS, MD, *Sumita Dutta*[1], MBBS, MD, *Kana Bal*[1], MBBS, MD, *Jayanta Biswas*[2], MBBS, MD

INTRODUCTION The superficial and deep palmar arterial arches are the main sources of blood supply to all structures in the human hand, and variations in these arterial arches are quite common. Although several studies have reported diameters and variations of these arches, to the authors' knowledge, no study has correlated such changes to handedness in adults. It is likely that dominance may play a role in arterial variations, such as those seen in the diameter or number of arteries formed in the palmar arches, much like in other areas of the human body. This cadaver study was conducted to determine any such association.

METHODS 42 formalin-fixed hands were dissected to expose the superficial and deep palmar arches. These arches were then thoroughly examined for any variations between the dominant and non-dominant hands. All cadavers were noted to be right-handed as per hospital records.

RESULTS 19 complete superficial arterial arches (right hand 14; left hand 5) were found in the 42 hands dissected.

CONCLUSION Most complete superficial palmar arches were found in the dominant hand of the cadavers studied, and therefore, handedness may have a role to play in determining palmar arterial arch variations in humans. Due to dominance or handedness, some arteries may likely persist into adulthood while others may become obliterated, thus leading to variations. Dissection of foetal hands may help to shed more light on the persistence or obliteration of various arteries after birth. Knowledge of such variations may prove helpful for surgeons during hand surgeries.

Keywords: handedness, palmar arches, variations
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INTRODUCTION

Copious bleeding following hand surgeries has prompted detailed studies of the arterial supply of the human hand since ancient times. Arterial variations in the human hand were first mentioned by Tiedman as early as 1831, and the first detailed comparative study of the hands of humans and primates was done by Smith in 1910.[1] The palm has a complex vascular architecture. To maintain a continuous supply of blood, the palm has arterial arcades that are formed by communicating arteries, so that blockage of one artery and resultant anoxia or hypoxia would not hamper the performance of the highly active small muscles of the hand. The formation of these arterial arcades is most probably predetermined genetically and maintained after birth.[2] In addition, the formation of smaller arteries could also safeguard against the incomplete development of arterial arches.[3]

The ulnar artery, accompanied by the ulnar nerve medially, enters the palm superficial to the flexor retinaculum and divides into the superficial and deep branches beneath the palmaris brevis. The superficial palmar arch (SPA), a dominant vascular structure in the palm of the hand, together with the deep palmar arch, then supply blood to all fingers in humans. The superficial branch, which is the direct continuation of the ulnar artery, contributes the most in the formation of the SPA.[4] The SPA lies between the palmer aponeurosis and the long flexor tendons, and may be complete or incomplete. When the arch is complete, the ulnar artery usually joins with either the superficial palmer branch of the radial artery, the arteria princeps pollicis, the arteria radialis indicis or the median artery. Branches of the SPA form the four common palmer digital arteries. The medial palmer branch passes along the ulnar side of the little finger, while the other digital arteries proceed forward up to the web spaces in-between the fingers, where each of them joins the palmer metacarpal artery, which is a branch of the deep palmer arch. Each common digital artery then divides into two proper digital arteries and supplies adjacent sides in between two fingers.[4] Meanwhile, the deep palmer arterial arch of the hand lies deep to the long flexor tendons and lumbrical muscles. This arch, which is formed by the anastomosis between the terminal end of the radial artery and the deep branch of the ulnar artery, gives off the following branches:[4] three palmar metacarpal arteries, three perforating arteries and recurrent branches. Rarely, the arch is incomplete.[4]

In humans, the SPA, which is more prominent than the deep palmar arch,[5] is thicker and supplies a majority of the muscles of the palm. The ulnar artery is the dominant arterial source of the SPA.[6] The human thumb muscles, which require a rich blood supply due to the evolution of its opposing movements, are solely supplied by the superficial branches of the radial artery in most human hands.[7] Conversely, in members of Ponginae, such as orangutans, gorillas, chimpanzees and sometimes gibbons, the deep palmar arch is multiple and plays a more important role in supplying blood to the hands than the SPA.[7] A possible reason

[1]Medical College, Kolkata, India, [2]Institute of Post Graduate Medical Education & Research, Kolkata, India
Correspondence: Dr Aniruddha Sarkar, Assistant Professor, Medical College, 88 College Street, Kolkata 700073, West Bengal, India. drani77@gmail.com

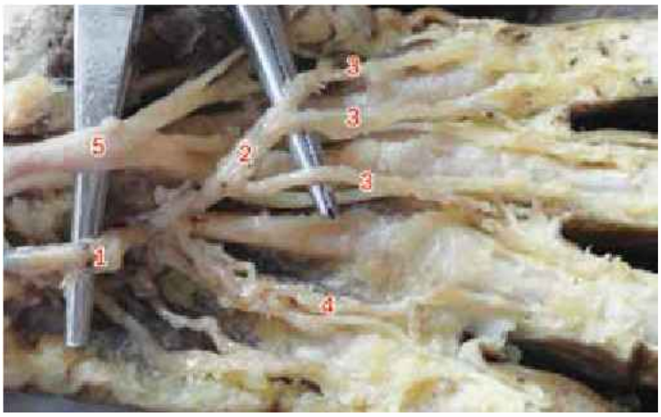

Fig. 1 Photograph shows an incomplete superficial palmar arterial arch supplying the medial 4½ fingers of the left hand. 1: ulnar artery; 2: superficial palmar arch; 3: common digital arteries; 4: proper digital artery; 5: median nerve

Table I. Findings of the cadaver study.

Finding	No. (%)
Type of SPA	
Complete	19 (45.23)
Incomplete	23 (54.76)
No. of complete SPAs	
Right hand	14 (73.68)
Left hand	5 (26.31)
Type of incomplete SPAs (No. of digits supplied by the ulnar artery)	
Type I (3½)	10 (43.47)
Type II (4½)	7 (30.43)
Type III (2½)	3 (13.04)
Type IV (1½)	3 (13.04)

SPA: superficial palmar arch

for this may be that in these animals, the SPA is more vulnerable to injuries.

Although several studies have reported on various aspects of the palmer arterial arches, to the authors' knowledge, no study has attempted to ascertain whether variations in arterial architecture exist between the dominant hand and the non-dominant or idle hand in human adults. It is likely that dominance may play a role in arterial variations, such as those seen in the diameter or number of arteries formed in the palmar arches, much like in other areas of the human body. A majority of the world's population (70%–90%) is believed to be right-handed,[8] and with this in mind, the present study was designed to study the differences in the pattern of blood supply between the right (dominant hand) and left (non-dominant) hands in human cadavers. Knowledge of the arterial arches in the hands is critical for orthopaedicians and microvascular surgeons, as variations in the pattern of blood supply are frequently encountered in hands, and awareness and identification of such variations is thus crucial during hand surgery. Recent progress in hand surgery has engendered the need for precise knowledge of the frequency of anatomical variations in the SPA and its branches.[9] Therefore, for surgeons performing advanced surgical procedures, such as reconstructive hand surgeries, such knowledge is pivotal.

METHODS

A total of 42 hands (right hand 21; left hand 21) of 21 right-handed embalmed human cadavers (fixed in 10% formaldehyde) were studied after proper dissection at the Department of Anatomy, Medical College, Kolkata, India. Anomalous dilatations, aneurisms and atheromatous or occlusive diseases of the palm were excluded at the beginning of the study. After proper skin incision, the superficial fascia, palmar aponeurosis and deep fascia covering the thenar and hypothenar muscles were separated from the flexor retinaculum and turned distally, taking proper care to preserve the underlying vessels and nerves. The SPAs immediately beneath the palmar aponeurosis were observed carefully, their formation and branches noted, and photographs taken. The flexor retinaculum was divided by a sagittal incision between the thenar and hypothenar muscles. Tendons of the flexor digitorum superficialis and profundus were cut in the forearm along both ends of the SPA and the tendons reflected distally. The adductor pollicis muscle was cut between its origin and insertion to expose the deep palmar arch, and the latter's formation and branches were observed carefully and noted.

RESULTS

Variations were observed in the formation of the SPA. In two (4.76%) hands, the SPA was formed by an anastomosis between the superficial branch of the ulnar artery and a branch from the deep palmar arch, with the latter coming to the superficial level at the base of the thenar eminence to join the ulnar artery. In three (7.14%) hands, the ulnar artery supplied only the fifth finger and the ulnar side of the fourth finger through a medial proper digital branch and a lateral common palmar digital branch, which reached the fourth web space. The remaining fingers received blood supply from the radial artery. There was no anastomosis seen between the ulnar and radial arteries. The radial artery provided two common palmar digital branches, which reached the second and third web spaces and divided into proper digital branches to supply the radial side of the fourth, the whole of the third and the ulnar side of the second finger. Three proper digital branches supplied the thumb and the radial side of the second finger. In seven (16.66%) hands, the ulnar artery supplied all fingers except the radial side of the thumb, which received its supply from a single proper digital branch from the radial artery. The ulnar artery gave rise to all the palmar digital branches, and there was no communication between the radial and ulnar arteries (Fig. 1).

Table I summarises the findings of our study. Complete SPAs were observed in 19 (45.23%) of the 42 hands and incomplete SPAs in the remaining 23 (54.76%) hands. The subtypes seen among complete SPAs were: type I (n = 17, 89.47%), where the SPA was formed by an anastomosis of the superficial branch of the ulnar artery and the superficial palmar branch of the radial artery (radioulnar type, Fig. 2); and type II (n = 2, 10.52%), where the SPA was completed by an anastomosis between the superficial branch of the ulnar artery and a branch from the deep palmar

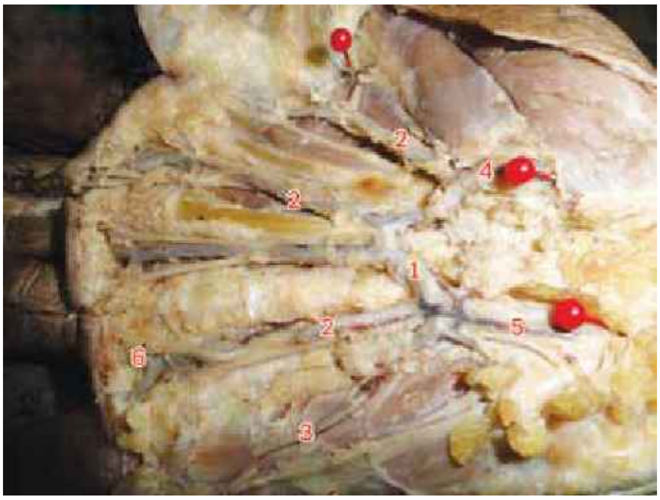

Fig. 2 Photograph shows a complete superficial palmar arterial arch and its branches in the right hand. 1: superficial palmar arch; 2: common digital arteries; 3: proper palmar digital artery; 4: superficial palmar branch of the radial artery; 5: superficial palmar branch of the ulnar artery; 6: proper digital artery

Fig. 4 Photograph shows an incomplete superficial palmar arterial arch supplying the medial 3½ fingers of the left hand. 1: ulnar artery; 2: radial artery; 3: incomplete superficial palmar arch; 4: arteria princeps pollicis; 5: palmar common digital arteries; 6: proper digital artery

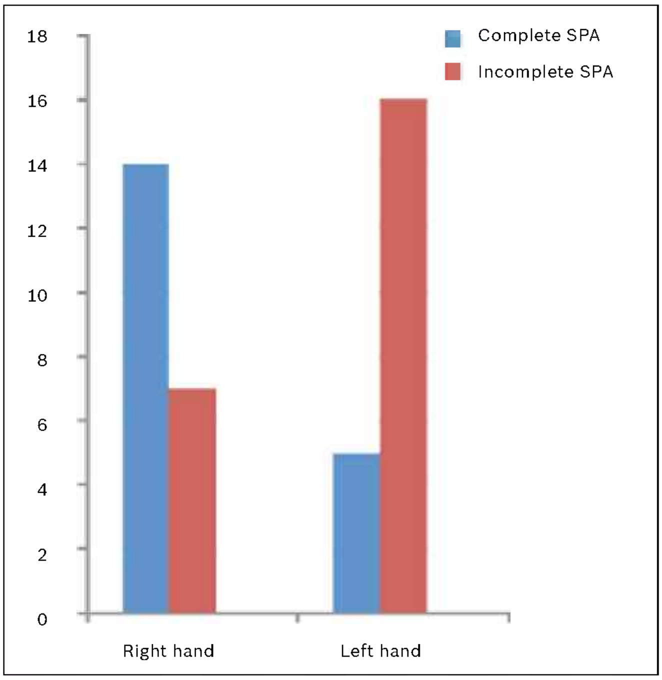

Fig. 3 Graph shows the comparison of complete and incomplete arterial arches seen in the dissected right and left hands.

Fig. 5 Photograph shows a complete deep palmar arterial arch and its branches in the right hand. 1: deep branch of the ulnar artery; 2: ulnar artery; 3: radial artery; 4: deep palmar arch; 5 & 6: palmar metacarpal arteries

arch, with the latter coming to the superficial level at the base of the thenar eminence to join the ulnar artery. The majority of complete SPAs were seen on the right side (14/19, 73.68%), with the left hands only showing five (26.31%) complete SPAs. Altogether, there were 21 right SPAs in the 42 dissected hands, with 14 (66.66%) complete SPAs and seven (33.33%) incomplete SPAs. Similarly, among the 21 left SPAs seen, there were five (23.80%) complete SPAs and 16 (76.19%) incomplete SPAs (Fig. 3).

Incomplete SPAs were found in 23 (54.76%) out of 42 hands, and all had blood supplies from both the ulnar artery and the superficial palmar branch of the radial artery without any anastomosis. These 23 hands were further divided into four subtypes based on the number of digits supplied by the ulnar artery. In type I (n = 10, 43.47%) hands, the ulnar artery supplied the fifth, fourth, third and the ulnar side of the second digit (or 3½ digits). The radial side of the index finger and the whole of the thumb were supplied by branches of the radial artery (Fig. 4). In type II (n = 7, 30.43%) hands, the ulnar artery alone supplied the fifth, fourth, third, second and the ulnar side of the thumb (or 4½ digits). Only the radial side of the thumb was supplied by the radial artery (Fig. 1). In type III (n = 3, 13.04%) hands, the ulnar artery supplied the fifth, fourth and the radial side of the third digit (or 2½ digits). The remaining 2½ digits received their blood supply from the radial artery. In type IV (n = 3, 13.04%) hands, the ulnar artery supplied only the little finger and the ulnar side of the fourth digit (or 1½ digits). The remaining 3½ digits were supplied by the radial artery.

The ulnar and radial arteries gave rise to the common palmar digital branches in their respective web spaces, where each artery divided into two proper digital branches to supply the neighbouring sides of the adjacent fingers as usual. The little finger received a separate proper digital branch from the ulnar artery, which supplied the ulnar side of that finger. There were no unusual communications between the common digital arteries or between the common and proper digital branches. This pattern was observed in all 42 dissected palms. Variations in the deep palmar arch were less frequent than in the SPA. All 42 hands showed complete deep palmar arches, with the arch being formed by the deep palmar branch of the radial artery anastomosing with the deep palmar branch of the ulnar artery as usual (Fig. 5).

DISCUSSION

Many variations in the SPAs were observed in our cadaver study with regard to the parent arteries giving rise to the SPA (with the radial, ulnar and median arteries being involved to varying extents) and the completeness of the arch. Although various studies have reported variations in the palmar arterial arches, similar variations were not observed in dissections of the deep palmar arches in the same cadavers. Unlike the findings of Patnaik et al[1] and Bataineh and Moqattash,[2] most of the arterial arches seen in our study were incomplete (54.76%), and complete SPAs were mostly found in the right hands (73.68%). We found that a majority of fingers were supplied by type I (43.47%) and type II (30.43%) incomplete SPAs formed by the ulnar arterial branches. The superficial palmar branches of the radial artery played a major role in type III (13.04%) and type IV (13.04%) incomplete SPAs. Interestingly, all cadavers were recorded as right-handed in our hospital records. Even though the sample size in our study was small, complete arterial arches were mostly seen in the dominant or right hand (14/19, 73.68%). No other variations were observed during our dissections.

Variations in the palmar arterial arches are very common, and therefore, knowledge of the arterial arches of hands, their formation and source of supply can be of much importance to medical and surgical practitioners alike. In various vascular reconstructive surgeries, for instance, although the radial artery is used as an arterial graft, detailed knowledge of arterial anastomoses in the palms is important to prevent vascular insult to the palm muscles. Similarly, an understanding of the common arterial variations possible in the palmar arterial arches would be fundamental to the success of repair procedures in patients with hand trauma, particularly in plastic surgeries or during arteriografting.

Although several studies have reported variations in the palmar arterial arches, to the authors' knowledge, no study has correlated such changes with handedness in humans. It is possible that dominance, which may be genetically determined, might have a role to play in these arterial variations. This cadaver study, which set out to uncover the association between handedness and arterial variations in human palms, found that most complete arterial arches were seen in the dominant hands of the cadavers dissected.

Bilateral dissections of foetal hands may prove helpful in detecting differences between the arterial arches of the two hands, although Maher,[10] in a study of 50 pairs of foetal hands, reported that there was no difference between the right and left hands of the foetuses studied. Indeed, one would expect to see some changes if the development of arterial arches was followed from the foetal stage up to adulthood, as it is likely that some arteries would persist into adulthood due to dominance or handedness, while others that are obliterated would give rise to variations and incomplete arterial arches. Studies on the differences in the arterial arches between the dominant and non-dominant hands are few, and therefore, this area holds much scope for future studies. Another object of research would be variations in the presence of the median artery. Further studies with a larger sample size, which follow the development and variations of the palmar arterial branches from the foetal stage to adulthood, would be needed to ascertain any such associations.

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