An atypical anatomical variation of palmar vascular pattern

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ABSTRACT

A complex variation in the pattern of blood supply to the palm of the hand was encountered during a routine dissection of a female adult cadaver. Findings were: (a) there was no communication between the superficial palmar branches of the radial and ulnar arteries (incomplete superficial palmar arch); (b) the superficial palmar branch of the radial artery coursed superficially to the thenar muscles supplying two common palmar digital arteries for adjacent sides of the thumb and index finger, thereby replacing the conventional arteria radialis indices; (c) the branch supplying the lateral side of the thumb was seen arising from the deep branch of the radial artery; (d) the superficial palmar branch of the ulnar artery supplied a branch to the medial side of the little finger, and two common palmar digital arteries for the adjacent sides of the little and ring fingers and ring and middle fingers, respectively. Familiarity with the variations in the vascular patterns resulting from a number of developmental errors remains the crucial issue for personnel engaged in reconstructive hand surgery, where these varied patterns act as pivotal points around which successful accomplishment of various advanced surgical procedures revolve.

Keywords: arterial pattern in hand, dominant blood supply, radial artery, superficial palmar arch, ulnar artery

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Fig. 1 Photograph shows the palmar aspect of the right hand. 1: SPRA (superficial palmar branch of radial artery); 2: SPUA (superficial palmar branch of ulnar artery). Note the absence of communication between these two vessels.

Fig. 2 Photograph shows the branching pattern of SPRA. Note the two common palmar digital arteries (1, 2) arising from SPRA; 1: giving proper digital branches for adjacent sides of the thumb and index finger (arrows); 2: giving proper digital branches for adjacent sides of the index and ring fingers (arrows).

INTRODUCTION

The anatomy of the palmar vascular arches and their variations, being one of the most challenging anatomical areas, have long intrigued clinicians and radiologists. Besides gross dissections and cast techniques,[1] angiography,[2] ultrasonography[3,4] and Doppler studies[5] have been incorporated in order to understand the complex but fragile vascular patterns of the palmar region. Recent advances in innovative microsurgical procedures for reconstructive hand surgeries have necessitated an in-depth understanding of these vascular patterns, the comprehensive knowledge of which remains the key issue in determining the appropriate technical feasibility of surgical interventions and successful outcome of the same.

Conventionally, the superficial palmar branch of the ulnar artery (SPUA), the superficial palmar branch of the radial artery (SPRA) and arteria radialis indices are described as contributing vessels in the formation of superficial palmar arch (SPA) with the ulnar artery as the main feeding vessel.[6] The SPUA is the direct continuation of the ulnar artery and forms the

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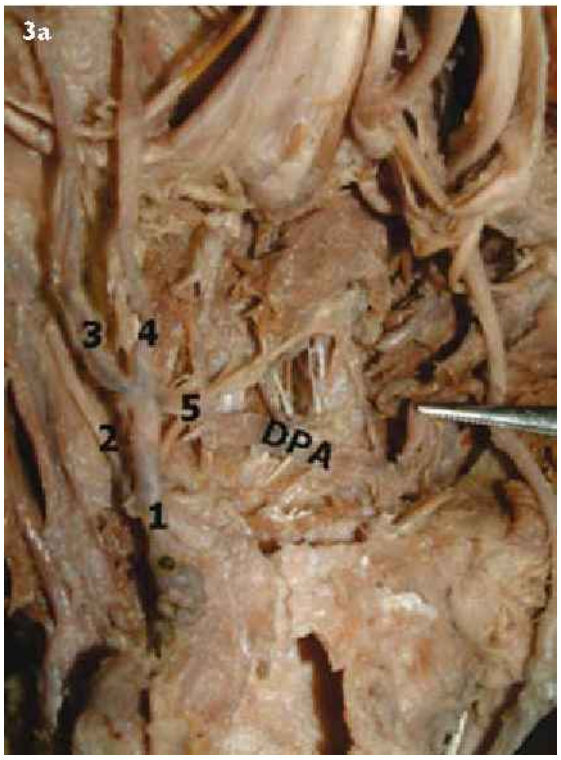

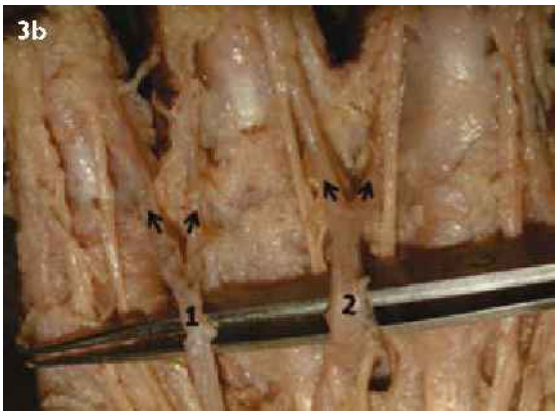

Fig. 3 (a) Photograph shows the branching pattern of SPUA (1). Note the branch going towards the medial side of the little finger (2). 3 & 4: common palmar digital branches of SPUA; 5: deep branch of the ulnar artery. (b) Magnified photograph shows two common palmar digital arteries (1, 2) arising from SPUA and giving proper digital branches to the adjacent sides of the little and ring fingers (arrows) and adjacent sides of the ring and middle fingers (arrows), respectively.

main contribution of the SPA.[7] Variations are more commonly encountered with SPA, with most of the variations being present on the radial side,[8] whereas the pattern of deep palmar arch (DPA) remains relatively constant. The fact that SPA is the main vascular structure of the palm, hence the familiarity about the possible variations in its pattern, is especially important for the surgeons dealing with reconstructive hand surgeries (congenital malformations, post-traumatic deformities or general procedures) and those concerned with restoration of the functional anatomy of the hand.

CASE REPORT

A unilateral variation in the pattern of SPA was noted during routine dissection of the right hand in an adult female cadaver. Elaborate dissection carried out in the palm revealed an absence of communication between the SPRA and the SPUA (Fig. 1). SPRA, lying lateral to the tendon of flexor carpi radialis, traversed superficially to the thenar muscles to reach the palm. Subsequently, two common palmar digital arteries arising from it supplied the adjacent sides of the thumb and index finger and the adjacent sides of the index and middle fingers through proper digital branches (Fig. 2). The SPUA after its origin from the main ulnar artery supplied a branch to the medial side of the little finger at a more proximal level (Fig. 3a) whereas the common palmar digital arteries arising from SPUA supplied the adjacent sides of the little and ring fingers and adjacent sides of the ring and middle fingers through proper digital branches (Fig. 3b).

At the wrist, SPRA was seen arising 3 cm proximal to the tubercle of trapezium (Fig. 4a) whereas the main trunk of the radial artery (deep branch), after traversing the anatomical snuff box, passed between the two heads of first dorsal interosseous (Fig. 4b) to gain entry into the palm. In the palm, the first branch arising from it traversed to the lateral side of the thumb, whereas the main continuation curved in a medial direction and anastomosed with the deep branch of the ulnar artery at the base of the fifth metacarpal bone, thus completing the DPA (Fig. 5). The formation of SPA in the left hand followed the conventional description, being contributed by the SPUA and SPRA with proper communication between the two.

DISCUSSION

The conventional arterial blood supply to the human hand is well-documented.[9-11] Variability in the vascular supply to the hand as well as the digits through SPA have been reported.[1,5,12,13] The classification of SPA into a complete or incomplete category based on the presence or absence of a communication between the vessels contributing to its formation was put forth as early as 1897.[14] This classification system holds true to date as it provides the simplest understanding of anatomic distribution of arteries. Three types of SPA, such as ulnar type (59%), the radioulnar type (32%) and the medianoulnar type (9%), based on the nomenclature reflecting the vessels taking part in its formation, was described in 1928.[15] The classical study on vascular

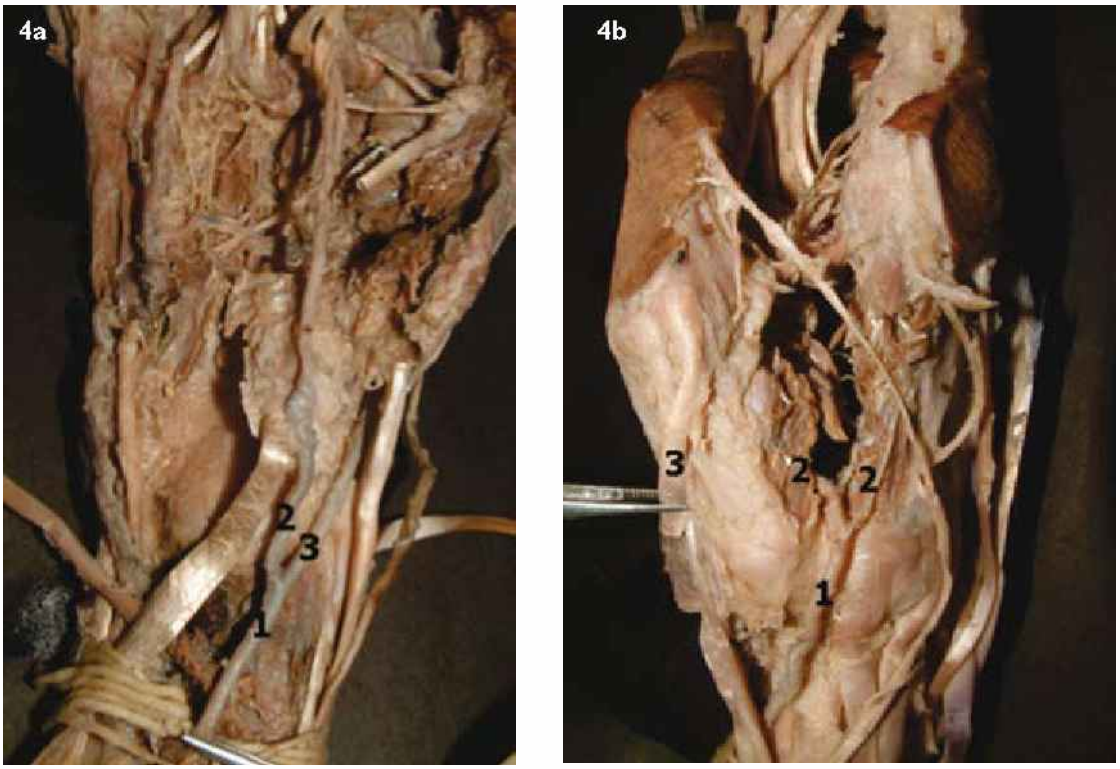

Fig. 4 (a) Photograph shows the division of the radial artery (1) into SPRA (2) and its continuation as the main trunk (deep branch: 3). SPRA passes superficially to the thenar muscles to reach the palm whereas the main trunk passes to the anatomical snuffbox. (b) Photograph shows passage of the main continuation of the radial artery (deep branch: 1) through two heads of the first dorsal interosseous muscle (2) to gain entry into the palm. 3: tendon of abductor pollicis longus.

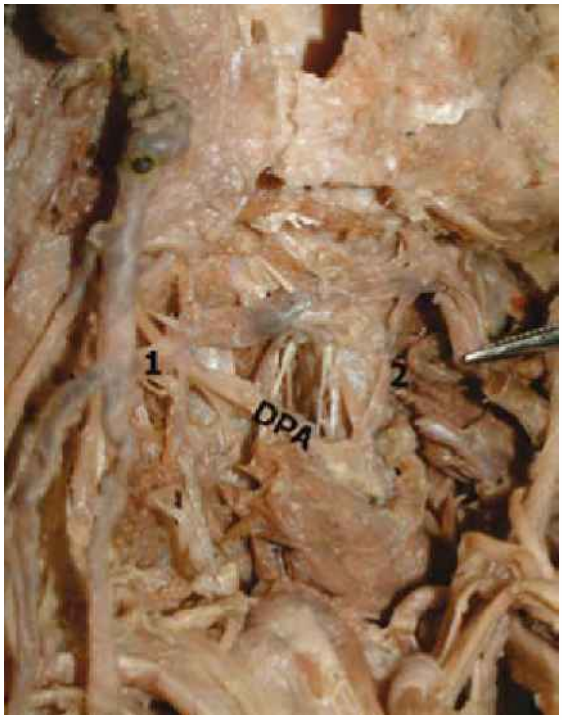

Fig. 5 Photograph shows the formation of the deep palmar arch (DPA) by contribution of the main continuation of the radial artery (2) and deep branch of the ulnar artery (1).

patterns in hand reported seven types of branching of SPA, regardless of its being complete (78.5%) or incomplete (21.5%).[16] The most predominant type in this series (77.3%) was the presence of four common digital arteries, the first supplying blood to the ulnar side of the thumb and radial side of the index finger, whereas the remaining three passed to the second, third and fourth web interspaces. A detailed study of the arterial pattern in 200 formalin-fixed hands was undertaken, and the incidence of incomplete and complete SPA reported by these investigators was 10% and 90%, respectively.[17] In this study, the predominant type of complete SPA (40%) was contributed by the superficial palmar branches of the radial and ulnar arteries, followed by the type where complete SPA was formed entirely of the ulnar artery (35%). These investigators also reported the predominant type of DPA being contributed by anastomosis of the deep palmar branch of the radial artery and inferior deep branch of the ulnar artery (60%), followed by type II (30%) formed by anastomosis of the deep palmar branch of the radial artery and superior deep branch of the ulnar artery.

SPA has been described to be of the complete or incomplete type, based on the presence or absence of anastomosis between the vessels constituting it.[1] In order to visualise the arterial system in hand, these investigators injected Ward's red latex or Batson's compound under pressure in 45 fresh limbs. According to their observations, complete SPA was

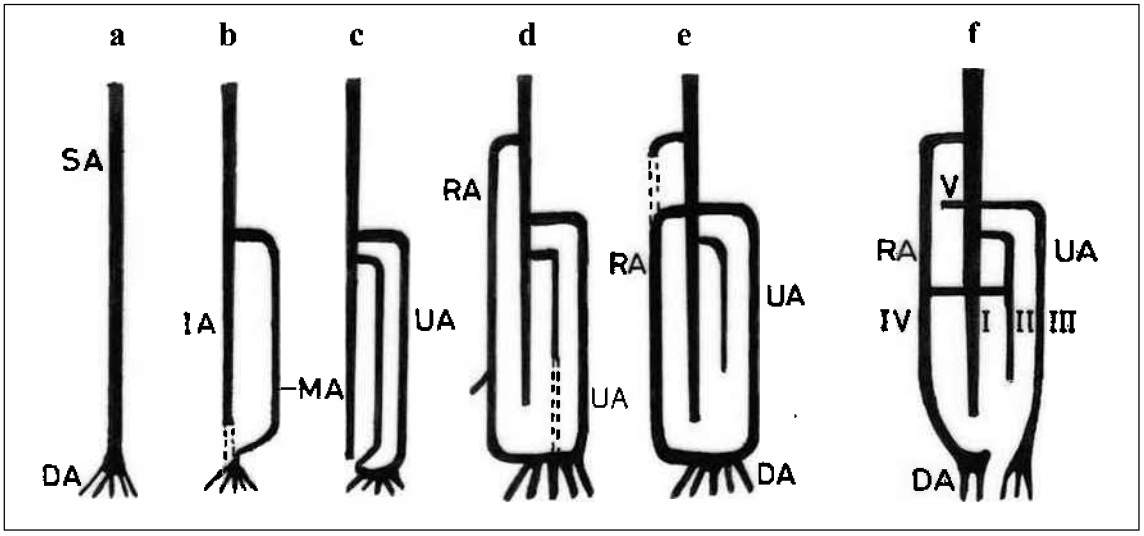

Fig. 6 Stages in the development of the arterial pattern of the upper limb. Schematic diagrams show (a) the subclavian-axillary (SA) artery traversing the limb bud and dividing into digital arteries (DA); (b) the primary axial artery brachial artery (BA) in the arm and interrosseous artery (IA) in the forearm. Note the median artery (MA) arising from the brachial artery and annexing the digital branches. (c) Ulnar artery arising from the brachial artery and communicating with the median artery. (d) Radial artery (RA) arising from the brachial artery and completing the arch formation with the ulnar artery. (e) The final rearrangement of vessels. (f) The arterial pattern seen in the present study. Note the absence of communication between the RA and UA.

present in 84.4% of specimens, with the predominant type of complete SPA (35.5%) being contributed by superficial palmar branches of the radial and ulnar arteries, followed by the type where SPA was entirely formed by the ulnar artery (31.1%). The incidence of incomplete SPA was reported in 15.5% of specimens by these investigators with the predominant type (11.1%) which entirely comprised the ulnar artery but with no contribution of the arterial supply to the thumb and index finger, whereas the rarer type (4.4%) comprised the superficial branch of both radial and ulnar arteries with no anastomosis between them. Upper extremities (200) from fresh human cadavers were injected by coloured latex or by India ink and gelatin,[18] and dissected under dissecting microscopes. Based on the observations of this study, these investigators concluded that SPA is the main vascular structure of the palm supplying the superficial flexor tendons, flexor retinaculum, median and ulnar nerves, tendon of flexor pollicis longus, lumbricals, palmar aponeurosis and skin of the palm, thereby playing an important role in balancing between the vast supply and demand. These investigators further emphasised the importance of such type of data for surgeons engaged in reconstructive hand surgeries. In the present study, incomplete SPA occurred in one of 24 palms (4.2%). The incidence of incomplete SPA encountered in the present study is somewhat similar to that reported previously.[1] However, the incidence of blood supply to the medial side of thumb being provided by palmar digital branches of SPA was much lower in the present work with respect to a previously-reported incidence of 20%.[6] This variation could be the result of a difference in variables such as sample size. The blood supply for the lateral side of the thumb was provided by a branch of deep division of the radial artery.

Some radiographical studies of the arterial patterns in the limbs of newborn infants and full-term foetuses clearly reveal the adult arrangement of the arteries.[19] This indicates that the factors producing departures from the so-called normal patterns might be active either at the embryonic or foetal stage. From the developmental point of view, the limb bud appears in the form of small elevations along the ventrolateral body wall during the fourth week,[20] and soon acquires a primitive capillary plexus in association with branches of intersegmental arteries arising from the aorta. The subclavian-axillary artery (the sole arterial stem of the upper limb) is identifiable in a 5-mm embryo,[21] where it extends to the wrist by dividing into terminal branches for fingers (Fig. 6a). The primitive vascular pattern consists of a primary axial artery (the brachial artery in the arm and interosseous artery in the forearm) with the median artery branching off from the brachial artery, which in turn annexes the vessels of hand and corresponds to stage II (Fig. 6b). In the 18-mm embryo, the ulnar artery (one of the prominent vessels of the forearm) arising from the brachial artery, unites distally with the median artery to form the arch pattern (Fig. 6c); this pattern corresponds to stage III.[22] Following this,

the radial artery (another prominent vessel of forearm) arises from the brachial artery and finally takes over the vessels of the hand corresponding to stage IV (Fig. 6d). This rearrangement (stage V) reaches completion before the end of the eighth week (Fig. 6e).[21] During this developmental period, unforeseen arrests, incomplete development or absorption of parts of vessels otherwise usually distinct, could form the basis of a final outcome different than the corresponding developmental stage and accounting for anomalous vascular patterns identified in later life.

The SPA has received substantial attention in the recent times on account of its importance in contributing towards the vascular supply of the hand, one of the most important tools of evolutionary advancement in humans. The pattern of SPA in the present study was similar to Type G described previously,[1] where both the radial and the ulnar arteries contributed to the superficial palmar arch but no anastomosis exists between the two. This pattern makes both vessels equally dominant anatomical components of the SPA. The implications of such varied vascular patterns cannot therefore be underestimated, keeping in mind the role of contributing vessels in determining the dominance in the vascular patterns of the hand.[11] This holds immense importance, especially for surgeons dealing with innovative microsurgical procedures for reconstructive surgeries of the hand. With drastic advancements in interventional procedures, the susceptibility of the radial artery to post-procedural trauma has increased manifold, subsequent to its ever increasing use in cannulation procedures, such as transradial angiography, transradial angioplasty and radial artery harvesting. With the type of incomplete SPA encountered in the present study (Fig. 6f), the arterial supply shows an increased vulnerability following trauma, thereby raising the chances of development of ischaemic changes in the distal hand. Hence, prior examination of the vascular anatomy of the hand in advance of a planned hand surgery is advised, since deviations from the normal anatomical patterns at the sites of interventional surgeries demand attention for modification of various criteria adapted either for the management or for the subsequent successful outcome.

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