International Journal of Medical and Health Research
www.medicalsciencejournal.com
ISSN: 2454-9142
Received: 02-03-2021, Accepted: 04-04-2021, Published: 11-05-2021
Volume 7, Issue 5, 2021, Page No. 04-08

A study on variations in the formation of superficial palmar arches and its clinical significance in hand surgeries

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Abstract
The superficial palmar arch (SPA) is a major source of blood supply to much of the palm and is conventionally formed by the union of the ulnar artery with the superficial branch of the radial artery. The SPA has been classified into complete or incomplete based on the presence or absence of anastomosis between the arteries contributing to the formation of this palmar arch. The present study was undertaken to study the morphology of the Superficial Palmar Arch and observe the variation in its formation with an emphasis on its clinical relevance. The study was conducted on 21 formalin fixed randomly selected hand cadaver sample specimens of both male and female genders procured from the Department of Anatomy, Osmania Medical College, Hyderabad, Department of Clinical Anatomy, Rajiv Gandhi Institute of Medical Sciences, Adilabad and Surabhi Institute of Medical Sciences, Siddipet, Telangana, India. On careful and meticulous dissection, out of 21 hand cadavers studied, twenty cadavers showed the classic SPA. In all these cases the arch was formed by anastomosis between superficial branches of radial and ulnar arteries (95.24%) and incomplete superficial palmar arches was observed in 1 (4.8%) cadaver sample. The variation from the normal classical pattern was observed in 1 (4.8%) cadaver, aged about 65 years showed the formation of superficial palmar arch by the median artery (a. nervi mediana). Right side anterior interosseous artery gave origin to the median artery, which is accompanying median nerve (uncommon). This artery participated in the formation of superficial palmar arch. The median artery after taking origin from anterior interosseous artery ran along median nerve for about 2 cm, then pierced the nerve and passed lateral to it up to the flexor retinaculum. It passed under flexor retinaculum, later joined the ulnar artery to form superficial palmar arch. Hence, the comprehensive knowledge of such anatomical variations of the vascular supply for the hand is very important for successful surgeries and better outcome.

Keywords: median artery, radial artery, superficial palmar arch, ulnar artery

Introduction

The superficial palmar arch (SPA) is a dominant vascular structure of the palm located deep to the palmar aponeurosis. It is a major source of blood supply to much of the hand and is conventionally formed by the union of ulnar artery with the superficial palmar branch of the radial artery. On entering the palm, it curves laterally deep to the palmar aponeurosis and superficial to the long flexor tendons, thus completing the arch by anastomosing with the superficial palmar branch of radial artery [1, 2].

It gives off four palmar digital arteries; the medial most supplies the medial side of the little finger and is called the proper palmar digital artery. The other three are common palmar digital arteries which subdivide into two and supplies the contiguous sides of the little, ring, middle and index fingers respectively [3].

Vascular patterns of the palmar arches and their interconnecting branches present a complex and challenging study. Classification of superficial palmar arch has been put forth by many researchers. The SPA has been classified into complete (show anastomoses) or incomplete (fail to anatomose) based on the presence or absence of anastomosis between the arteries contributing to the formation of this palmar arch [4, 5, 6]. Adachi [7] classified SPA under three broad categories as ulnar type, radio-ulnar type, median-ulnar type depending on the arteries contributing.

Coleman and Anson [8] classified the superficial palmar arch in two groups, Group I and Group II. Group I - Complete Arch: Contributing vessels anastomose with each other which are further divided into five types. Group II - Incomplete Arch: Contributing vessels do not anastomose with each other which are divided into four types such as, A, B, C, D similar to Group I (except Type E which has no representation in Group II).

The SPA has been reported to be highly variable with regard to its origin and branching pattern in the hand. The anatomy of the palmar vascular arches and their variations is one of the most interesting and challenging anatomical areas.

Variations in the superficial palmar arch have been studied by several authors. The palm is entirely supplied by both the SPA and deep palmar arch (DPA) with their anastomosis. Vessels of the palm bleed profusely but at the same time heal rapidly as like the scalp owing to a good anastomosis.

As the SPA is the main arterial supply to the palm, the knowledge on the details of its possible variations is essential and basic requirement of all the aspiring hand surgeons, in microsurgical techniques, reconstructive hand surgeries, pre-operative screening of the radial artery harvesting for myocardial revascularization and also in arterial interventions that include radial artery cannulation and radial artery forearm flap [9].

The objective of present study was to study the morphological variations of SPA in adult human to enable

help in planning and improving microsurgical techniques to achieve the best results.

Materials and Methods

The present study was conducted on 21 (n = 21) randomly selected hand cadaver sample specimens procured from the Department of Anatomy, Osmania Medical College, Hyderabad, Telangana, India, the Department of Clinical Anatomy, Rajiv Gandhi Institute of Medical Sciences, Adilabad and the Surabhi Institute of Medical Sciences, Siddipet, Telangana, India. All the cadavers were embalmed with 10% formalin solution and were stored with subsequent tagging of their respective numbers, age and gender. Ethical clearance was obtained from the College Ethical Committee.

Out of 21 specimens obtained, 12 were of male and 9 of female gender, age ranging between 18 - 75 years. Inclusion criteria included intact palms of disarticulated upper limb specimens. Exclusion criteria included those cadavers which exhibited some pathologies, previous trauma to the upper limb, fractures before death and also fractures after death due to poor handling during transportation and storage and also any kind of surgical procedures performed particularly in the hand.

The dissection of the hands was performed as per the procedure given by Cunningham's manual of practical anatomy [3]. The limbs were carefully dissected from the level of the wrist joint on the palmar aspect till the web spaces. The superficial branches of radial and ulnar arteries were identified, the branching pattern and course was traced. The morphology of SPA was studied and variations were observed and photographed.

Results

In the present study, on careful and meticulous dissection, out of 21 (13 were right side and 8 were left side samples) hand cadavers studied, twenty cadavers showed the classic SPA. In all these cases the arch was formed by anastomosis between superficial branches of radial and ulnar arteries (95.24%) and incomplete superficial palmar arches was seen in n = 1 (4.8%) cadaver sample. There was no anastomosis between superficial branches of radial and ulnar arteries.

The variation from the normal classical pattern was observed in 1 (4.8%) cadaver sample, aged about 65 years showed the formation of superficial palmar arch by the median artery (a. nervi mediana). Axillary and brachial arteries were observed normal in both the upper limbs. Brachial artery was divided into radial and ulnar arteries in the normal way. The origin and branching of interosseous arteries was observed arising from ulnar artery (left UL), in both the upper limbs which is common (Fig 1). Right side anterior interosseous artery gave origin to an artery, which is accompanying median nerve (uncommon). This artery is called median artery (a. nervi mediana) and this artery participated in the formation of superficial palmar arch (Fig. 2). Median artery after taking origin from anterior interosseous artery ran along median nerve for about 2 cm (Fig. 3). The median artery then pierced the nerve and passed lateral to it up to the flexor retinaculum (Fig. 4). It passed under flexor retinaculum, later joined the ulnar artery to form superficial palmar arch (Fig. 5).

In normal course of the radial artery contributing to the formation of superficial palmar arch by the radial artery was absent. Remaining course of radial artery was noticed to be normal (Fig. 6). Normally the course of radial artery shows at the wrist the artery winds dorsally (Fig. 7), leaves the dorsal surface of the wrist through a triangular gap between the two heads of first dorsal interosseous muscle, where the artery is crossed superficially by the extensor pollicis longus tendon (Fig. 8).

The deep palmar arch was formed by the anastomosis between the terminal end of radial artery and the deep branch of ulnar artery. Here before forming the arch, the radial artery gave off two branches – arteria princeps pollicis and arteria radialis indicis (Fig. 9).

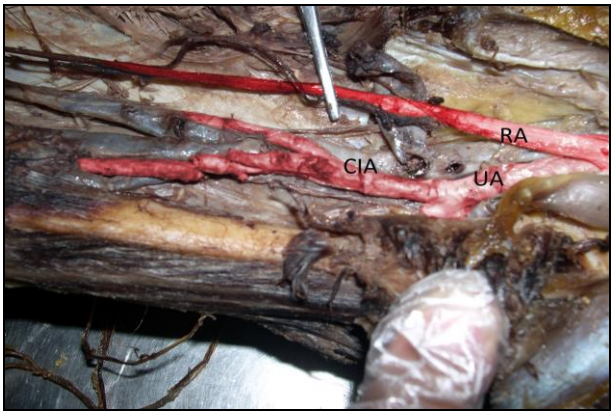

Fig 1: Origin and branching of interosseous artery from ulnar artery (left UL)

Fig 2: The median artery (a. nervi mediana) participated in the formation of superficial palmar arch

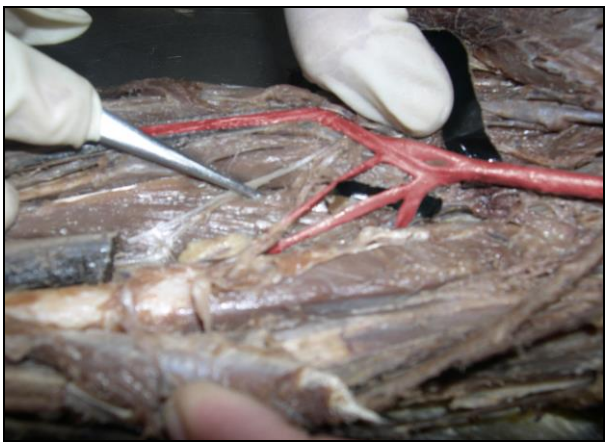

Fig 3: Median artery after taking origin from anterior interosseous artery ran along median nerve for about 2 cm

Fig 4: The median artery pierced the nerve and passed lateral to it upto the flexor retinaculum

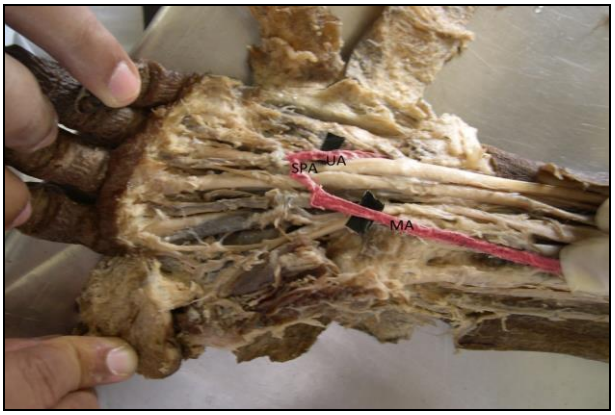

Fig 5: It passed under flexor retinaculum, later joined the ulnar artery to form superficial palmar arch. (flexor retinaculum removed)

Fig 6: Normal course of the radial artery: Contribution to superficial palmar arch by the radial artery is absent. Remaining course of radial artery is normal

Fig 7: Normal course of radial artery: At the wrist the artery winds dorsally

Fig 8: Normal course of the radial artery: Leaves the dorsal surface of the wrist through a triangular gap between the two heads of first dorsal interosseous muscle, where the artery is crossed superficially by the extensor pollicis longus tendon.

Fig 9: Formation of deep palmar arch: It is formed by the anastomosis between the terminal end of radial artery and the deep branch of ulnar artery. Here before forming the arch, the radial artery gave off two branches – arteria princeps pollicis and arteria radialis indicis

Discussion and Conclusion

The vascular anatomy of the upper limb is a complex and challenging area and has been the subject of many studies. One of the major problems involved in surgical approaches of the limbs is the occurrence of a strange anomalous arterial pattern [10] which is due to the complicated mechanism of derivation of arteries from a simple type of axis artery of the limb. This axis artery disappears during the second embryonic month. However, it sometimes remains in the forearm as the median artery [11].

The median artery as a component of the SPA has been described in the literature. The percentages of hands in which the median artery made a contribution to the superficial palmar arch were reported to be 2.2% [12], 6% [13]. The present study results showed the prevalence of median artery (a. nervi mediana) contributing to the formation of superficial palmar arch in 4.8% cadaver samples. In contrast to our results, several authors in different studies reported the prevalence of median artery contributing to the formation of SPA in 9.9% (Coleman and Anson, 1961), 16% [14], 8% [15], 8.4% [16] and 9.5% [17] cadaver samples.

The origin of median artery has previously been described as arising from the common interosseous artery, anterior interosseous artery, and ulnar arteries frequently [11, 18 - 23].

However, it can also arise from the brachial artery, superficial brachial artery, and deep brachial artery [24 – 26]. Very rarely, the median artery arose from the radial artery [27, 28]. Varley *et al*. [29] reported that the arising of median artery from the radial artery may increase the risk of hand ischemia if the radial artery is damaged during harvesting. In the present study, we observed the median artery taking origin from anterior interosseous artery ran along median nerve for about 2 cm, which then pierced the nerve and passed lateral to it up to the flexor retinaculum. It passed under flexor retinaculum, later joined the ulnar artery to form superficial palmar arch. Hence, the results suggested that in the event of the above situation, the surgeons must be vigilant in order to ensure that its origin is not ligated during harvesting [29].

The present study showed 95.24% complete arches and 4.8% incomplete arches similar to the study results reported by Ikeda *et al*. [30], Vidya *et al*. [31] and Suma *et al*. [9]. The Indian studies results showed the prevalence of high percentage of complete arches when compared to the other population studies (Table 1).

Table 1: Showing the distribution of complete and incomplete arches in various studies

Study	Country	Sample size	SPA type in percentage	
			Complete arch	Incomplete arch
Coleman and Anson [8]	USA	650	78.5	21.5
Ikeda et. Al. [30]	Japan	220	96.4	3.6
Al-Turk and Metcalf [32]	USA	50	84	16
Loukas et. al. [33]	USA	200	78	16
Fazan et. al. [34]	Brazil	46	48	52
Bilge et. al. [35]	Turkey	50	86	14
Sarkar et. al. [36]	Singapore	42	45	55
Patnaik et. al. [37]	India	50	78	16
Vidya et. al. [31]	India	50	92	8
Suma et. al. [9]	India	20	95	5
Joshi et. al. [38]	India	100	82	18
Present study (2021)	India	21	20	1

The SPA is formed in 1/3rd of cases by the ulnar artery alone; 1/3rd by anatomosing with the superficial palmar branch of the radial artery and another 1/3rd by anastomosing either with the arteria radialis indicis or with arteria princips pollicis or with the persistent median artery [8, 39, 40].

In the present study the SPA is formed by the anastomosis between the terminal end of radial artery and the deep branch of ulnar artery. Here before forming the arch, the radial artery gave off two branches – arteria princeps pollicis and arteria radialis indicis.

The present study results suggest that the knowledge of median artery is important in surgical procedures of hand. Identifying the median artery is also important as its presence may cause carpal tunnel syndrome. The identification of any variation in the arterial pattern of the hand using various techniques is of great importance in various surgical interventions of the hand. The data on the variations of the arches will certainly be useful for surgeons while performing reconstructive surgeries on hand and proposing new microsurgical techniques.

However, it is important to note that the present study results with small sample size representative of small subset of human population are not sufficient to make a final conclusion as this type of studies has to be conducted with large sample size in all the regions all over our country to ascertain the correct percentage of prevalence of variations in the formation of SPA. Hence the knowledge of such anatomical variations of the vascular supply for the hand and branching patterns is very important for the surgeons for a successful surgery and also to achieve the best results and also proposing newer and safer surgical procedure.

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