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Cadveric Study of Superficial Palmar Arch

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Abstract: *Awareness of the anatomical variations of the blood supply of the hand is necessary for the anatomist but also for surgeons when considering hand surgeries. The objective of this study was to find the incidence of anatomical variations of the superficial palmar arch and describe any anatomical variation. 18 cadavers were observed for this during routine dissections of MBBS graduates in Andhra Medical College, Visakhapatnam. In one of the cadavers there is no superficial palmar arch but the ulnar artery alone is seen suplying the medial 3 digits. And the superficial palmar branch of radial artery never joined the ulnar or niether of its branches joined to complete the arch. But in turn the superficial palmar branch of Radial artery supplied the thumb and index finger. Knowledge of vascular anamolies of the hand should be borne in mind to avoid iatrogenic injuries during surgery of the hand.*

Key Words: *Anatomical variations, superficial palmar arch, radial artery, ulnar artery, digital arteries.*

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I. Introduction

The terminal branches of radial and ulnar arteries supply the hand. The superficial and the deep palmar arches SPA and DPA are the chief suppliers of hand. The superficial palmar arch (SPA) is mainly formed by the ulnar artery. It enters the palm along with the ulnar nerve,on its medial side anterior to the flexor retinaculum and lateral to the pisiform. As it enters it passes through guyon's canal which is formed by pisohamate ligament connecting the hook of hamate which lies medially. Then it curves laterally to form an arch, convex distally and level with a transverse line through the distal border of the fully extended thenar eminence. The superficial palmar arches are formed by the ulnar; and are completed by the superficial palmar branch of the radial artery or by the arteria radialis indicis, a branch of arteria princeps pollicis or the median artery. Four digital arteries arise from the convexity of the arch and pass to the fingers. The most medial artery is a proper digital artery and supplies the medial side of the little finger whereas the remaining three are common palmar digital branches which are joined by metacarpal arteris at the web spaces and further divide into two now called as proper palmar digital branches and supply the contiguous sides of the little, ring, middle, and index fingers, respectively. The superficial palmar arch is covered by palmaris brevis and the palmar aponeurosis and lies superficial to flexor digiti minimi, branches of the median nerve and to the long flexor tendons and lumbricals.

The anatomy of the hand is of significant interest to various disciplines of science. A complete knowledge of the arterial supply of the hand is imperative when carrying out procedures like radial artery conduits in coronary artery bypass grafting (CABG), radial artery cannulation and reconstructive surgeries of the hand. The Vascular pattern of the palmar arches and their interconnecting branches present a complex and challenging study.

The vascular anatomy of the hand is challenging due to a high prevalence of previously identified variations. The variations were most found in the superficial palmar arch (SPA), through which the hand receives its major blood supply. The SPA has been described to be broadly divided into two categories: complete and incomplete. The difference resides in the presence or absence of an arch formed either by a single artery or between the constituting vessels. Variations are more prevalent within the complete arch. The variations that occur in the arch are known to be more frequent on the radial side. This may involve one or more interconnecting branches. In view of its importance, the study of the intricate vascular pattern of SPA has continued to receive much interest following advances in microsurgical procedure for reconstructive hand surgery. Awareness of the frequency of these arterial variations has been observed to be of great assistance in preparation and planning for safe hand surgery. Such procedures are now preceded by arterial cannulation in order to determine the exact vascular pattern and hence minimize any potential tissue damage. The objective of this study was to find the incidence of anatomical variations of the superficial palmar arch and describe any anatomical variation unknown.

II. Materials And Methods

A total of 18 cadavers of both sexes (15 men and 3 women) with different age group were used for the study. Upper limb region of (36 sides) of the cadavers were carefully dissected as per the standard dissection procedure in the department , Andhra medical College. The hands were dissected by first removing the skin covering the flexor surface of the hand with a slight extension proximal to the wrist joint and then distally in the palm to the bases of the digits. The ulnar and radial arteries identified proximal to the wrist. All of the collected superficial palm Arches were allocated according to the classification of Lippert and Pabst (1985), which determines two main types: Complete and incomplete arches. A complete arch (Type A) is found when there exists an anastomosis between at least two arteries. Following subtypes can be determined [from reference 11]:
LPA1 ("classic" radioulnar type or Arcus radioulnaris): Anastomosis between the ulnar artery and the superficial branch of the radial artery.
LPA2 (medianoulnar type or Arcus medianoulnaris): Anastomosis between the ulnar and median artery.
LPA3 (radiomedianoulnar type or Arcus radiomedianoulnaris): Anastomosis between the ulnar, median and radial artery.
LPA4 (profundoulnar type or Arcus profundoulnaris): Anastomosis between the ulnar artery and the deep branch of the radial artery as the first dorsal interosseus artery or deep palmar arch.
LPA5 (medianoradial type or Arcus medianoradialis): Anastomosis between the superficial branch of the radial artery and the median artery.

An incomplete arch (Type B) does not provide any anastomosis with following subtypes:
LPB1: the ulnar artery forms an arch without anastomosis to other vessels (ULNAR type). LPB1a is including branches to the ulnar side of the thumb and LPB1b is supplying including the index but not the thumb.
LPB2: ulnar and radial artery reaches the palm and gives branches to fingers. Fig(1)
LPB3: ulnar and median artery reaches the palm and gives branches to fingers.
LPB4: ulnar, median and radial artery reaches the palm and gives branches to fingers.

III. Results And Discussion

In the right hand: Brachial artery terminates into radial and ulnar artery in the cubital fossa and the radial artery runs superficial in the forearm and on reaching the wrist curves dorsally and crosses the anatomical snuff box and the ulnar artery enters the hand superficial to the flexor retinaculum along with the ulnar nerve.

In the left hand: Brachial artery terminates into radial and ulnar artery in the cubital fossa and the radial artery runs superficial in the forearm and on reaching the wrist curves dorsally and crosses the anatomical snuff box and the ulnar artery enters the hand superficial to the flexor retinaculum along with the ulnar nerve. The ulnar artery lies lateral to the nerve throughout its course and its superficial branch forms the superficial palmar arch.

All the 36 hands were dissected to study the SPAs. 26 hands showed the normal LPA –1 type of SPA- about 72.2 % .

One of the female cadaver showed that Arteria Princeps Policis arising from the SPA. SPA is formed from the ulnar and radial artery deep branch. Comes around 5.5%.fig:3

Another male cadaver showed the contribution from median artery corresponding to arcus mediano ulnaris of LPA2 type. Fig:2. There is no contribution from radial, radialis indicis and APP are arising from SPA alone. Which shows about 5.7%..

Other variants are branches arising from single point like a flower . Which is about 5.7%. Fig:4. Arch is a complete arch.

Another variation is that radial artery gives rise to a slender branch which helps in completion of the arch, and the arch is completed by this slender branch.radial artery gives branches to the thumb and index finger as usual. Fig:5

FIG: 1 RT HAND LPB 2 TYPE

FIG: 2 LT HAND COMPLETE ARCH LPA 2 TYPE (ARCUS MEDIANOULNARIS)

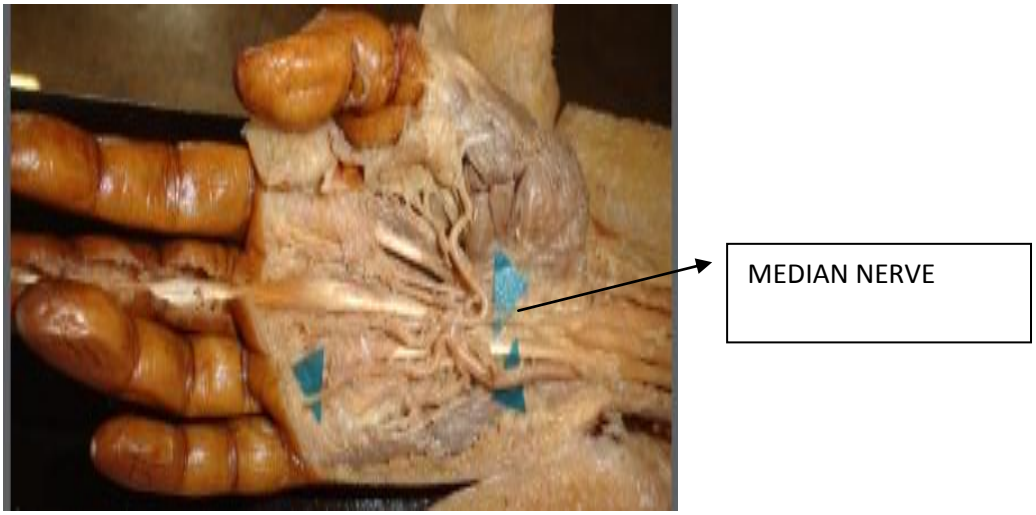


FIG: 3 LPB1A RT.HAND FEMALE

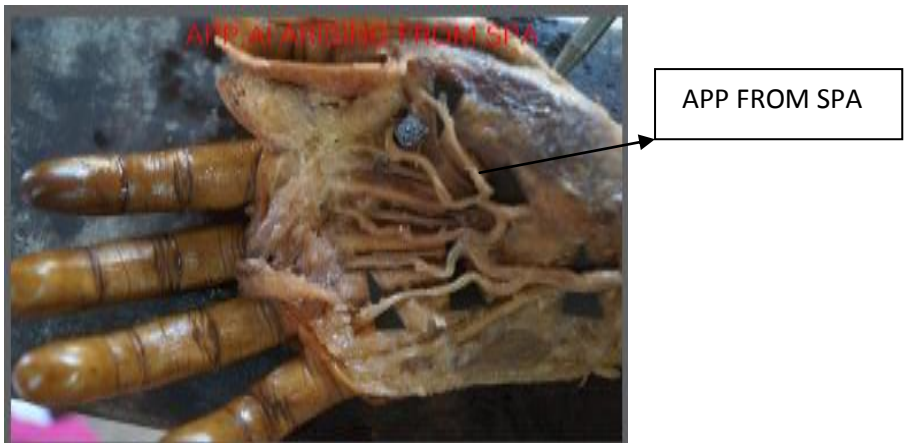


FIG: 4

FIG: 5 JOINED BY SLENDER BRANCH

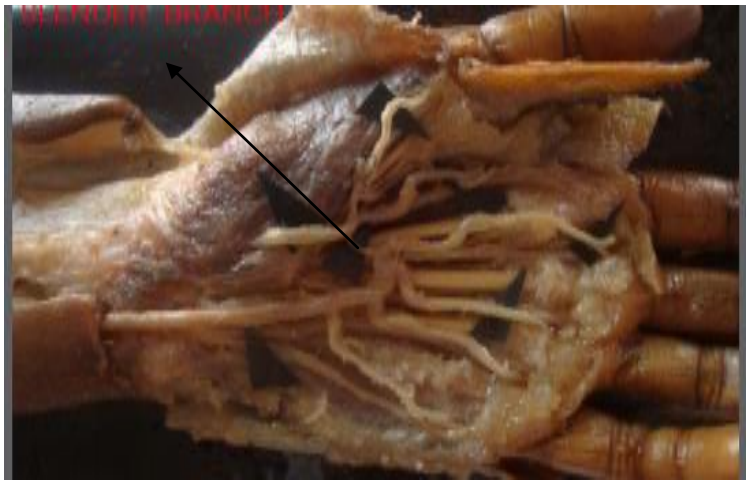


TABLE:

TYPE OF ARCH	ARTERIES CONTRIBUTION	NO: SPECIMENS	%
TYPE A (COMPLETE)LPA1	RADIAL & ULNAR	26	72.2
LPA- 2 (COMPLETE)	RADIAL & MEDIAN	2	5.5
INCOMPLETE LPB 2	ULNAR ALONE	2	5.5
LPB1A (INCOMPLETE)	APP&AI FROM ARCH ALONE	2	5.5
COMPLETE LPA	FROM A COMMON POINT	2	5.5
COMPLETE	JOINED BY SLENDER BRANCH	2	5.5

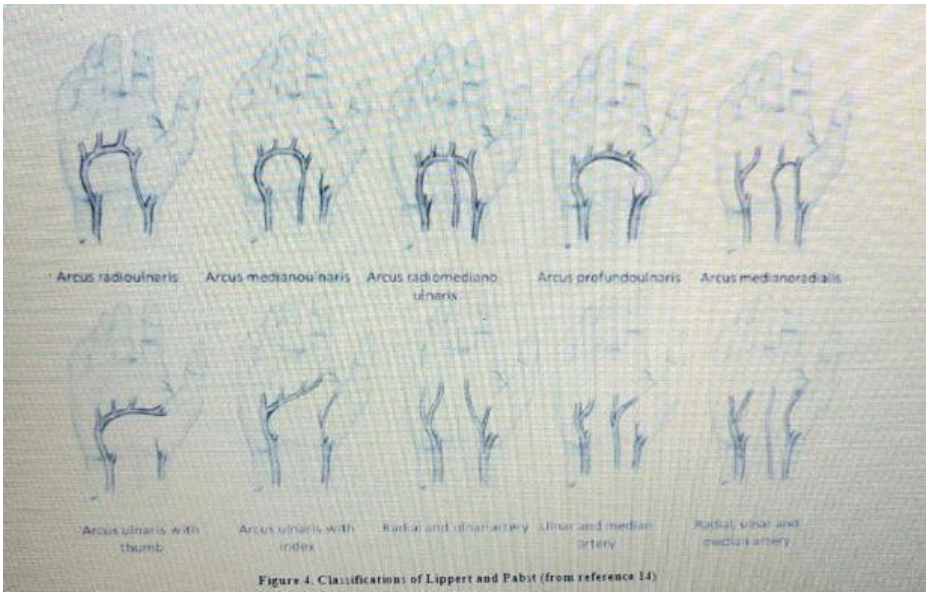
First descriptions of variations of the superficial palmar arch(SPA) were collected in the 19th century. Jaschtschinski [11], created a classification concerning the variability of SPAs. This was used by other authors Coleman and Anson [3], Gellman et al [5]; Ikeda et al [7]. Jaschtschinski [11] described complete and incomplete arches with different subtypes. In the category of complete arches he lists the radioulnar arch, medianoulnar arch, radiomedianoulnar and ulnar arch. Latter one is the most important to be an arch formed by the ulnar artery only. Jaschtschinski subdivides the ulnar arch as well developed to send arteries to the thumb's both sides or a "weak" developed one with the first palmar digital common artery to reach only the thumb's ulnar side. However, he clearly determines the ulnar arch to reach the entire thumb or parts of it. This is what we can see in fig: 3. a well developed type of ulnar artery.

In this study we tried to follow the Jaschtschinski's classification but defined an arch as complete in case of ananastomosis between vessels. But this cannot be followed because Jaschtschinski's ulnar arch does not contain any anastomosis. In addition, Coleman and Anson [3] have found a not yet described type providing an anastomosis between the ulnar artery and the deep arch. Well, this corresponds to one subdivision of Jaschtschinski's radioulnar arches. Regarding other, later published papers such as Gellman et al. [5], they include the same concept as Coleman and Anson [3]. However, Lippert and Pabst [13]. published a classification to be in contrast to Jaschtschinski's due to its terminology because they determined a complete arch in case of anastomosis between at least two vessels no matter how large the anastomosis might be. As a consequence, Lippert and Pabst [13] list 4 subtypes of complete arches and 5 subtypes of incomplete arches. Most important difference is that Jaschtschinski's ulnar arch in not found in the category of complete but incomplete arches. Additionally it is defined as a variation to reach at least radial side of the index.

The superficial palmar arch is an arterial arcade which lies adjacent to the palmar aponeurosis. The arch begins on the flexor retinaculum immediately distal to the pisiform bone; it crosses the hook of the hamate deep to the Palmaris brevis. It turns laterally and pierces the medial septum of the palm. It continues deep to the palmar aponeurosis to anastomose with branches of the radial artery as mentioned above. The superficial palmar arch has many branches the main ones being the four digital arteries [2]. The superficial palmar arch can be complete or incomplete. Incomplete superficial palmar arches are clinically important because individuals who have them are at increased risk of digital ischemia. In a study by Coleman et al., the complete arch was found in 78.5% of the cases and incomplete arch in the remaining 21.5% [3]. A study conducted by Ikeda et al. using 220 cadaveric specimens identified the complete superficial palmar arch in 96.4% of the cases and an incomplete palmar arch in 3.6% [7].

Gellman et al. showed a complete superficial palmar arch in 84.4% of cases [5], while Al Turk and Metcalf also reported complete superficial palmar arch in 84% of the cases [15]. According to Williams P et al, about one - third of the SPA is formed by the ulnar artery alone; a further third is completed by the superficial palmar branch of the radial artery and a third either by the arteria radialis indicis or by the princeps pollicis or by the median artery (The median artery is a branch of the anterior interosseous artery which is a branch from the ulnar artery. The median artery arises in the forearm and accompanies the median nerve) [15]. Furthermore this study states that the classical type of the superficial palmar arch in which the superficial branch of the ulnar artery anastomoses with the superficial branch of the ulnar artery is found in only 34.5% of cases. In 2009 a study was done by Bataineh et al using 30 formalin fixed cadaveric hands. A rare case was reported in there study in which an incomplete superficial palmar arch was formed by the median artery which gave rise to the princeps pollicis and radialis indicis arteries [2,16].

Figure 4. Classifications of Lippert and Pabst (from reference 14)



Little et al. [17] noted that the circulatory dynamics in the hand follow a very variable pattern, the ulnar artery being the dominant source of supply in the most hands. They concluded that collateral circulation in the hand would generally maintain viability of fingers when either radial o ulnar artery was occluded at the wrist. However, they found that in 9% of the hands, there was drastic disturbance of circulation on occlusion of ulnar

artery. They suggested that the variation in collateral adequacy in the hand may explain ischaemic phenomena seen in some patients with the hammer hand syndrome [21].

Hypothenar hammer syndrome occurs in persons who use hand as a hammer. Any finger could become ischaemic following occlusion of ulnar artery or superficial volar arch depending upon the pattern of branching present in the superficial arch and the distribution of digital arteries [18,21].

Loukas et al [19] reported a case of complete superficial palmar arch which had no contribution from radial artery and terminated by giving rise to a common trunk for the princeps pollicis and radialis indicis arteries. They stated that as the arterial supply of the thumb in this case is solely provided by superficial palmar arch, a potential hazard could exist in the event of traumatic injury to the ulnar artery [21].

Mookambicaet al [20] reported a case where the superficial palmar arch was formed exclusively by superficial branch of ulnar artery, without contribution by any other vessel. Ulnar artery continued as the first common digital artery to the interdigital cleft between index finger and thumb and this digital artery was dividing into arteria princeps pollicis (APP) or arteria radialis indicis (ARI). They called this type of arch as incomplete SPA based on Gellman classification of palmar arches. They stated that the nomenclature of arteries originating from SPA and supplying thumbs and index finger have to be discussed because of their surgical importance. In hand surgeries like vascular graft applications, arterial repairs, free/pedicle flaps clinicians should be aware of these variations, because in most of the traumatic events and the surgical procedures of hand, SPA plays an important role. In case of ulnar skin flaps, damage to the ulnar artery may present a risk. Interference with an efficient blood supply may result in inefficient utility of the movements of fingers and hand. Superficial palmar arch is the main vascular structure of palm. Hence knowledge about the variation in its pattern is important for surgeons dealing with reconstructive hand surgeries and restorations of functional anatomy of hand. Techniques like Doppler ultrasound, modified Allen test, pulse oximetry and arterial angiography or a combination of the standard Allen test and ultrasonography can be used to identify the vascular pattern of the palm [20,21].

With the recent advances in the field of endoscopic surgical removal of the radial artery reported by Connelly et al. [22] and their promising results, it is apparent that the use of the radial artery as a coronary artery bypass graft(CABG) is being met with some degree of approval. Connelly et al. [22]reported the use of the radial artery in 60% of coronary bypass cases. They reported a reduction in infection rate, discomfort, scarring and possible neurological deficiency, even in patients with such complicating factors as diabetes or peripheral vascular disease. The removal of the radial artery endoscopically can be performed by a properly trained physician's assistant in as little as 15 min. The reported poor longterm performance of saphenous vein grafts [23] allows one to remain cautiously optimistic regarding the use of this novel technique in the future.

Various diagnostic procedures have been implemented to assess the viable collateral circulation in the hand. Gull published a case of pseudoaneurysm in an eighty years old male which was diagnosed by using contrast enhanced computerized tomography angiography and Doppler, which were used to delineate the details of the aneurysm and the collateral circulation [24]. The modified Allen's test is considered as a primary screening method due to its feasibility and Doppler ultrasonography can be used as an alternative, in case unsatisfactory results are obtained by using the former test [25]. A collateral circulation is the remedy for diseases of the palm, which can be established by an anastomosis between the radial and the ulnar arteries [26]. The radial and the ulnar arteries are the main sources to the palm and the further supply can be added by the median and the interosseous arterial systems. The collateral circulation can be assessed by using the modified Allen's test, Doppler ultrasound, pulse oximetry and arterial angiography [27].

Developmental evidence suggests that on reaching the hand the ulnar artery links with the superficial palmar plexus from which superficial palmar arch originates, while the median artery loses its distal connection and is reduced to a small vessel. The superficial arch can be reinforced by a large median artery which arises frequently from the anterior interosseus artery [28]. The proportion of hands in which the median artery made a contribution to the superficial palmar arch was reported as 6% by Anitha et al.,[29]. Rodriguez et al described the palmer type of median artery, representing its embryonic pattern as large, long and reaching the palm [30]. They suggest that radial artery acquires its final state by stage 21 of the embryo and any variations in the formation of SPA may be due to persistence or enlargement of initial network of vessels which normally regress or remain as capillaries. Embryological basis for high origin of superficial ulnar artery and its contribution in the formation of SPA has been reported by Natsis et al. [31] and Reddy et al. [32]. Ikeda et al., [7] also suggest that an inhibition of the development of the vessels at different stages of the embryonic period may be the causes of arterial congenital anomalies.

In the present study, complete SPA formation was observes in 32 hands about88.8%. In the present case the only major communication between radial artery and deep branch of ulnar artery was completion of the deep palmar arch. This cadaver showed bilateral presentations of incomplete superficial palmar arch with an exclusive vascular pattern, which did not show absolute similarity with finding of the above mentioned studies.

Regarding the anatomical variation described, we believe that the knowledge of this unusual shape is extremely important, especially because the influence it can exert on the conduct of clinical or surgical procedures.

IV. Conclusion

The proper knowledge of frequency of anatomical variations of vasculature of the hand is very important for safe and successful procedures in order to avoid or minimize the risk of complications during vascular surgeries or reconstructive surgery in the hand. A review of vascular pattern prior to invasive or intervention surgery is strongly recommended, which would allow to detect anomalies likely to necessitate modification of surgical procedures.

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