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## REVIEW OF VARIATIONS OF RADIAL ARTERY

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### ABSTRACT

Radial artery is one of the smaller terminal branches of brachial artery which originates at the level of neck of radius. During routine dissection, a lot of variations in the arterial pattern of the upper limb were encountered which ignited our curiosity to review literature regarding the normal anatomy and variations of radial artery. There is marked difference in the arrangement of these arteries in different individuals as well as on the two sides of the body of same individual. Any of these may interfere in the clinical diagnosis and surgical management of a given case.

**Keywords-** radial artery, volar arch, anastomosis, variations, bifurcation

### INTRODUCTION

The aim of clinical medicine is to identify the problematic foci in normal anatomy and physiology, i.e. the pathology, and rectify the same and restore them to as normal as possible. These foci can be identified only with a sound knowledge of normal anatomy and all its variations.

Any physician or surgeon having anything to do with the radial artery “ought” to know the normal anatomy and variations of the radial artery to enable their “eye to see” all that their “minds know and want to do!”

It will help the anatomists in a greater understanding of the subject and to accordingly teach the relevant anatomy with more accuracy. As the radial artery is used in bypass surgery it is of immense help to know the exact location of the radial artery to harvest it for the Coronary Artery Bypass Graft (CABG). It helps the urosurgeons to make the arterio-venous fistula for the purpose of haemodialysis. Radial artery is also the preferred route for renal artery stenting.<sup>2</sup> It helps the radiologists in the diagnostic and therapeutic interventional procedures. Plastic surgeons

reconstruct severely damaged tissues with the help of fascio-cutaneous flaps based on radial artery forearm flap.

Accurate knowledge of the relationship and course of these arterial conduits and particularly of their patterns of variation is of considerable practical importance in the context of reparative surgery in the arm, forearm and hand.<sup>3</sup>

### HISTORY

McCormack et al have traced the following history of the record of arterial patterns in the upper limb.<sup>3</sup> In 1600, Laurentius described the variation in the arterial pattern. Eventually in 1831, Tiedeman first systematically described the variations in the arterial pattern of the upper extremities. In 1844, Quain was the first to provide sufficient data for useful statistical evaluation. In 1868, Henle provided an analysis of a large European series. Drizenko et al have mentioned that since 19<sup>th</sup> century, variations of the arterial network of the upper limb in man have aroused the interest of anatomists.<sup>4</sup> They also have quoted the classification first elaborated by Dubreuil-Chambardel in 1926 and by Adachi in 1928.<sup>4</sup>

Rodriguez-Baeza *et al* have described the variations in the arterial pattern of the upper limb quoting the following authors.<sup>5</sup> Frequently either in routine dissection or in clinical practice variations in the arterial pattern have been observed by Lippert and Pabst. Anatomy textbooks do make a reference to 'vas aberrans' in the main brachio-antebrachial pattern as described by Shafer and Thane, Testut and Latarjet, and Williams and Warwick.<sup>5</sup> Tountas and Bergman in 1993 have described these arterial variations in more detail and explanation for arterial variations in the human upper limb is generally based on the classical lines of arterial development according to Singer and Carlson as quoted by Rodriguez-Baeza.<sup>5</sup>

## DISCUSSION

According to Karlsson and Niechajev, who have quoted Muller and Quain, prevalence of anatomic variations in the arteries of upper limb based on autopsy reports, is quite variable from 14% to 19.5%.<sup>6</sup>

McCormack had studied the arterial patterns in 750 upper extremities and had observed that instances of origin of radial artery proximal to intercondylar line formed by far the largest group of variations. In his study, he found the above pattern in 14.27% of all specimens and 77 % of all the variations. He categorised variations of radial artery in two groups. In 2.13% of specimens radial artery arose from the axillary artery and in 12.4 % of specimens it arose from the brachial artery. He described variations of radial artery and categorised them on the basis of anastomotic connection, without considering any reference point for measurement.

### Group I

Those radial arteries, which made no significant gross anastomosis with other major vessels in the course through the arm and forearm.

### Group II

Those radial arteries in which an anastomosis was established with the deep or regular brachial artery

in the ante cubital region, the communicating vessels in these cases passing anterior to the biceps tendon.

### Group III

Those radial arteries in which long slender anastomosis with the brachial artery that passes posterior to the biceps tendon.

### Group IV

Those radial arteries in which there was anastomosis with the median artery.<sup>3</sup>

Drizenko described three cases of variant origin of radial artery.<sup>4</sup> In one case, he had observed bilateral instances of high origin of radial artery. Here, the brachial artery was situated at the lateral border of the median nerve and divided in the middle of the arm below the tendon of pectoralis major into two branches. The slender lateral branch skirted the medial border of biceps brachii muscle and then straddled the distal part of muscle to travel towards the elbow region. Beyond this, it had normal course in the forearm and hand. The stout medial branch remained in company with the posterior aspect of the median nerve up to the elbow. Beyond this it gave off interosseous trunk and ulnar arteries. In another case, the brachial artery had precocious bifurcation in the middle part of the arm into two branches i.e. medial and lateral. They then continued as radial and ulnar arteries .

Literature abounds with variations in the site of origin of radial artery. According to Keen, superficial brachial artery arose from the upper part of the brachial artery.<sup>7</sup> Actually it was bifurcation, because two trunks of equal diameter (3 mm) continued downwards, one superficial and other deep to the median nerve. The superficial brachial artery descended in the superficial fascia, and in front of bicipital aponeurosis and then bifurcated into radial and ulnar arteries. The more deeply placed trunk supplied interosseous, recurrent and muscular arteries.

Keen classified the superficial brachial artery into three types.<sup>7</sup>

- Superficial brachial artery that continued in the cubital fossa and then bifurcated as usual.

- Superficial brachial artery continued as radial artery known as high origin of radial artery.
- Superficial brachial artery continued as ulnar artery known as high origin of ulnar artery.

According to Jurjus immediately after the origin of the profunda brachii, the brachial artery bifurcated into the two brachial arteries of equal size.<sup>8</sup> These arteries were running parallel in the expected path of the brachial artery. Brachial artery I was possibly a high origin and persisting embryonic radial artery in the arm and in the forearm brachial artery I divided into two equal sized radial and ulnar arteries. In contrast the brachial artery II was the prospective common interosseous. The course of brachial artery II resembled the course of the brachial axis artery.<sup>8</sup>

Bergman studied arterial patterns in 610 upper extremities.<sup>9</sup> He had observed the usual textbook description of the axillary artery continuing as brachial artery in 80% specimens. However he had found a major variation i.e. a high proximal division of brachial artery into radial and ulnar arteries. This variation could occur at any point in the normal course, but was most common in the upper third of arm and least common in the middle third of arm. The radial artery arose from the brachial artery more proximally than usual, from the axillary artery, or from the brachial artery lower than the bend of elbow, but this low division of the brachial artery was rare.<sup>9</sup>

The double branching pattern of the brachial artery has been reported by McCormack and Rodriguez-Baeza et al, i.e. superficial and deep brachial artery.<sup>3,5</sup> Superficial brachial artery divided into the radial and ulnar arteries or sometimes as superficial ulnar artery and deep brachial artery continued as common interosseous artery.

Gonzalez-Compta described bilateral high origin of the radial artery, where the axillary artery divided into anterior and posterior branches, the anterior branch being the high origin of radial artery and posterior branch, the proper brachial artery.<sup>10</sup> The course and distribution of the radial artery was normal in the forearm.

Gonzalez-Compta had mentioned two types of variations.

High origin of radial artery because of precocious bifurcation.

Superficial brachial artery arising from brachial artery and providing radial and ulnar arteries and brachial artery proper continuing as common interosseous artery.

Rodriguez-Baeza et al studied the arterial patterns in 23 upper extremities and categorised the high origin of radial artery into two groups depending on whether a median artery was present or not. In three cases there was high origin of radial artery with the presence of median artery but the origin of radial artery was different in each case. In this pattern radial artery arose from upper third, middle third, lower third of the brachial artery. In four cases there was high origin of radial artery without median artery, in two cases it arose from axillary artery, whereas in others it arose from upper third of brachial artery.<sup>5</sup>

According to Nakatani superficial brachial artery continued as the common interosseous artery and the deep brachial artery continued as radial and ulnar arteries.<sup>11</sup> Proximal to the loop of lateral and medial pectoral nerve, the axillary artery branched and gave rise to the posterior circumflex humeral and subscapular arteries and then continued distally as the brachial artery. The profunda brachii artery arose 1 cm proximal to the lower border of pectoralis major. Brachial artery was 5 mm in diameter and divided 1 cm distal to the lower border of pectoralis major into superficial and deep brachial arteries. The superficial brachial artery 1mm in diameter crossed over the confluence of the medial and the lateral roots of the median nerve, descended ventral and lateral to the median nerve. Then it continued as the common interosseous artery. In the cubital fossa the common interosseous artery branched into the recurrent ulnar, median, posterior interosseous and muscular branches and then continued as anterior interosseous artery. Deep brachial artery passed dorsal and medial to the median nerve,

progressively spiralling ventral to it at the distal third of the upper arm. It split into radial and superficial ulnar artery. The radial artery gave off the recurrent radial artery and muscular branches and had a normal course in the forearm.<sup>11</sup>

Rodriguez – Baeza *et al* also described the superficial brachial artery usually continued beyond the elbow to give off the radial and ulnar arteries and brachial artery proper provided the common interosseous artery.<sup>5</sup>

Sahin described bilateral high origin of the superficial radial artery but with two different sites of origin in the same individual. On the right side, the superficial radial artery was a branch of the axillary artery and the axillary artery continued as the brachial artery becoming the ulnar artery in the cubital fossa. On the left side it came from the lateral side of the brachial artery midway down the arm and its later course and ramification was similar to the right superficial radial artery. It continued as the ulnar artery in the cubital fossa.<sup>12</sup>

Keen had described entirely different pattern of variation where an “arterial island” may form as mentioned by Adachi as “inselbildung” [German-island].<sup>7</sup> A small branch 2 mm in diameter which arose from the upper part of the brachial artery (5 mm) passed superficial to the median nerve and then rejoined the main trunk a short distance above the bifurcation in the cubital fossa.

Keen also described a large superficial brachial artery (6 mm in diameter) which arose from the upper part of the brachial artery and a small parallel artery (2 mm) running downwards deep to the median nerve at the level of the radio-humeral joint. These two vessels united again to form a single trunk. This artery bifurcated in the cubital fossa at the normal level below the radio-humeral joint.<sup>7</sup>

McCormack described accessory brachial artery arising from the brachial artery.<sup>3</sup> Throughout its course it was medial to the main brachial artery, however, midway in the arm it passed deep to the median nerve and 4 cm proximal to its termination

it crossed back over the median nerve and rejoined the brachial artery.<sup>3</sup>

McCormack while recording the presence of anomalous arteries in the upper limb has also measured the distance between the site of origin of radial artery and intercondylar line of humerus. He had found the variation of high origin of radial artery in 107 out of 750 cases and in 33 of them the distance of this origin, from intercondylar line ranged 15-19.5 cm.<sup>3</sup>

Mullan studied the variation in the bifurcation of brachial artery in 30 Caucasian cadavers. He recorded the bifurcation of brachial artery with reference to interepicondylar line. He had found high bifurcation in 15% (9/60).<sup>13</sup>

Bergman quoting of Quain noted that when the radial artery itself arises higher up, the radial recurrent artery usually comes from the residual brachial trunk or sometimes from the ulnar artery or more rarely from interosseous artery. A variation in origin of the radial recurrent artery was noted in relation to the anastomotic vessels. In this the radial recurrent artery arose from the anastomotic vessel within 1 cm of its junction with the radial artery.<sup>15</sup>

In his study, McCormack had noted that the course of radial artery remained normal even in cases of high origin. In our study also no variation was found in the course of radial artery in the forearm even in all cases of high origin of radial artery. It also maintained the normal relation with the superficial branch of radial nerve i.e. the nerve was lateral to the artery.<sup>3</sup>

Coleman and Anson in their exhaustive study arterial pattern in 650 specimens found that in 97% of cases the deep palmar (volar) arch was complete and it was less variable than superficial palmar (volar) arch.<sup>16</sup>

Absence of the radial artery is a relatively uncommon variation. Poteat has quoted Charles and Kandanoff and Balkansky having reported such cases. It may be the most primitive pattern and has potential embryologic and surgical significance.<sup>17</sup>

## CLINICAL SIGNIFICANCE

The knowledge of the arterial variation of the superior extremity is useful as one can get confused with veins, which can lead to accidental injection of anaesthetic agent in the artery leading to distal necrosis of limb.<sup>4</sup> Similar catastrophic sequelae were presented by Cohn and quoted by McCormack, e.g. accidental intra-arterial injection of Pentothal sodium leading to gangrene of forearm, hand and fingers.<sup>3</sup> It is essential for a surgeon to keep in mind the major arterial variations while performing certain surgical procedures. When a surgeon fails to recognize and ligate aberrantly originating radial arteries running in the depth of wounds, it can lead to serious haemorrhage.<sup>3</sup> In the radiological diagnostic studies for peripheral vascular diseases injection of contrast medium in the brachial artery sometimes may lead to opacification of palmar arches without the opacification of radial artery. This may lead to erroneous diagnosis of occlusion of radial artery without considering the possibility of high origin of radial artery. Similarly during the ascending catheterization, the interventional radiologists need to take into account the variation in the origin of radial artery before concluding their study.<sup>4</sup>

## CONCLUSION

The radial artery is an important arterial conduit from the clinical point of view and the radial artery is indispensable to anatomists, general surgeons, radiologists, plastic surgeons, and even cardiovascular thoracic surgeons.

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