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THE CLINICAL SIGNIFICANCE OF RADIAL ARTERY MORPHOLOGY IN ARTIFICIAL ARTERIAL-VENOUS FISTULA FOR HEMODIALYSIS

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ABSTRACT

The radial artery usually arises from brachial artery and begins just below the inferior border of teres major. The present study focuses on the radial artery features which are the internal diameter and external diameter as well as thickness of wall and origin level of radial artery to give extensive data for physicians. Present study comprises a dissection of 68 upper limbs which is 34 cadavers (14 female and 20 male cadavers, 34 rights and 34 left). The age range 37-96 years in which the radial artery was investigated. It usually arises distal to the superior margin of the head of the radius in 82.65%. The angle degree of radial artery with respect of brachial artery ranges from to 8^0 to 30^0. The internal and external diameters of the radial artery found to be decreasing gradually from proximal to distal in all cases. The right radial artery is more prominent than left one. The right radial artery is a proper choice to select in artificial arteriovenous fistula due its size. Selecting the right radial artery will increase the success rate of artificial arteriovenous fistula. Knowing the morphological of radial artery is essential for radiologists and and surgeons to avoid the iatrogenic faults. With variable morphology of the radial artery, there is a frequent vascular injury may happen during surgical operation. Therefore, identifying the thickness, diameter and variable origin level of the radial artery is clinically significant.

KEYWORDS: Brachial artery, Radial artery, Radial diameter, Radial thickness, artificial arteriovenous fistula

The brachial artery is a direct continuation of the axillary artery just below the inferior border of teres major passing distally and laterally and lying medial to biceps brachii and anterior to coracobrachialis and brachialis. In the cubital fossa, the brachial artery passes underneath the bicipital aponeurosis. It terminates as it divides into radial and ulnar arteries. Understanding the cubital fossa contents may have clinical significance. It is the triangular area on the ventral aspect of the elbow joint which bounded by pronator teres medially and brachioradialis laterally. It starts from the level of medial and lateral epicondyles of the humerus superiorly. The deep fascia of the arm and bicipital form roof of cubital fossa aponeurosis whereas the brachialis and supinator form the floor. The contents of the cubital fossa are the median nerve, brachial artery, the tendon of biceps brachii and radial nerve from medial to lateral direction. The brachial artery split into the radial and ulnar arteries at the apex of cubital fossa. The radial artery is the smaller of the two terminal branches of brachial artery. The radial artery usually arises at the level of the neck of the radius and passes along the lateral side of the forearm. It runs distally in the anterior part of the forearm. In the proximal half of the forearm it is located deep to brachioradialis, in the middle third of the forearm its lateral side is related to superficial branch of the radial nerve, while in the distal forearm it is covered only by deep fascia, superficial fascia, and skin and lies medial to the tendon of brachioradialis. In the distal forearm, the radial artery is located immediately lateral to the tendon of the flexor carpi radialis and directly anterior to pronator quadratus and the distal end of the radius. It then passes inferiorly between the heads of adductor pollicis and becomes the deep palmar arch, which joins with the deep branch of the ulnar artery. However, at the wrist it passes laterally through the anatomical snuff box and then between the heads of the first dorsal interosseous. Along its course it is accompanied by a similarly named vein, the radial vein (Standring ; 2005).

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radial artery is clinically significant. Consequently, the diameter of radial artery may add suggestions to the clinical management of therapeutic issues.

METHODS

Present study is a dissection of 34 cadavers including 14 female and 20 male cadavers which is in total 68 upper limbs specimens (34 rights, 34 left). The age range 37-96 years in which the radial artery was investigated. The current study has been conducted in centre for anatomy and human identification, University of Dundee in United Kingdom. It is under regulation and rule of United Kingdom research which has been approved from the chair of anatomy institution. The photo has been taken by using a camera 12 megapixels in which the permission for taking photographs has been granted under University of Dundee regulations. This dissection study was conducted on cadavers used for undergraduate teaching. The skin and fasciae has been removed and reflected to expose the muscles compartment of arm and forarm. Further, the pectoralis major and minor were reflected to expose the axillary artery. As soon as the axillary artery is identified, it has to be traced till the inferior border of teres major in which the brachial artery begins and passes distally. It is located medial to biceps brachii and anterior to coracobrachialis and brachialis. A carful observation of the brachial artery bifurcation into radial and ulnar artery according to the level of superior margin of the head of the radius has to be considered. It targets the origin of the radial artery and its internal and external diameters. The vernier calliper, ruler and a protractor are used are the measurement tools in this study (Figure 1, Figure2). For the radial artery, the means and associated standard deviations (mm) of the external and internal diameters and thickness of the radial artery are measured in three levels (at its origin, the common interosseous artery origin and wrist) in entire cases and both genders. In the cubital fossa, the origin angle of the radial artery from the brachial artery was measured. To measure the angles, an imaginary line drawn alongside brachial artery was used as a reference a point. In the forearm, the internal and external diameters of radial artery (proximal, middle, and distal portions) were measured too.

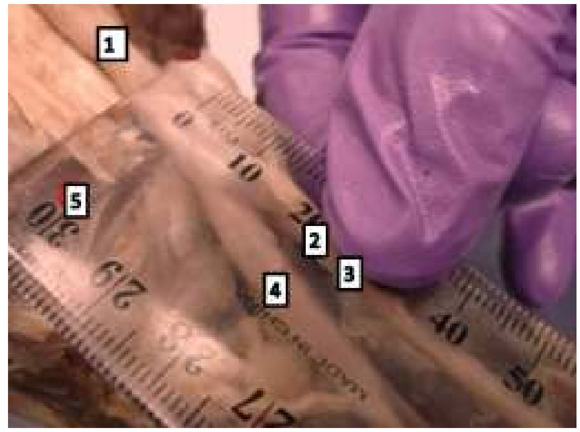

Figure 1: The measurement of the distance of radial artery origin from the superior margin of the head of the radius. 1-Brachial Artery, 2-Head of Radius, 3-Radial Artery, 4-Ulnar Artery, 5-Ruler

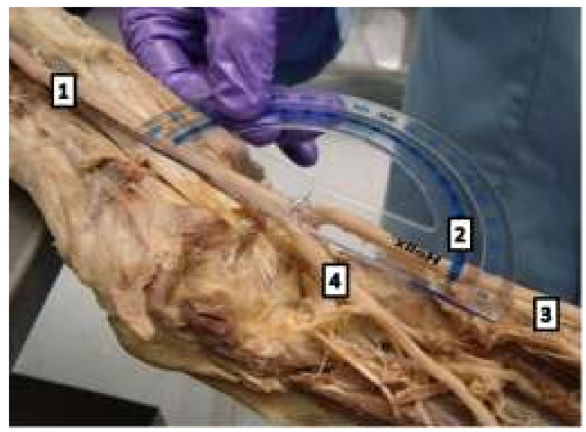

Figure 2: The measurement of the angle of radial artery to be taken. 1-Brachial Artery, 2-Protractor, 3-Radial Artery, 4-Ulnar Artery

RESULTS

The data were collected from both limbs 14 female and 20 male: the mean male and female ages were 81±7.2 and 75.9±16.3 respectively. The combined mean age is 78.9 with standard deviation of 11.9 years. The range of ages of all cadavers was 37 to 96 years. The present study includes 68 dissected upper limbs to investigate the ulnar artery origin, its internal diameter, external diameter, wall thickness and distance of ulnar artery origin. The data were collected and calculated to measure the mean and standard deviation. T-tests were performed to assess differences in arterial diameter between females and males and right and left sides, as well as along the length of ulnar artery.

In male, the means and the standard deviations as well as the range of origin angle of radial artery of the left side found to be 6.82mm, 6.8mm and 0-25^0 respectively. Whereas, the means and the standard deviations as well as the range of origin angles of radial artery of the right side found to be 19.9mm,8.56mm and 0-29^0 respectively (Table 1). In female, the means and the standard deviations as well as the range of origin angle of radial artery of the left side found to be 5.09mm, 6.21mm and 00-14.66^0 respectively. Whereas, the means and the standard deviations as well as the range of origin angle of radial artery of the right side found to be 4.88mm, 7.1mm and 0- 19^0 respectively. In total specimens, the means and the standard deviations as well as the range of bifurcation angles of ulnar artery of the left side found to be 18.64 mm, 5.63 mm and 0- 25^0 respectively. Whereas, the means and the standard deviations as well as the range of bifurcation angles of ulnar artery of the right side found to be 19.36 mm, 5.5 mm and 0-29^0 respectively (Table 1). Therefore, the range of angles of radial artery is 0-29^0. The mean angle of left female radial artery is significantly ($P<0.05$) larger than on the right.

Table 1: The means, the standard deviations and the range of origin angles of radial artery

Radial artery	Side	Mean (mm)	Standard Deviation (mm)	Origin of radial artery Proximal to superior margin of the head of the radius[a]	Origin of radial artery distal to superior margin of the head of the radius*	Range of angle degree of radial artery from brachial artery
MALE	Left	6.82	6.8	0% (0 out of 20)	100% (20 out of 20)	0- 25^0
	Right	19.9	8.56	25% (5 out of 20)	75%	0-29^0
FEMALE	Left	5.09^	6.21	0% (0 out of 20)	100% (14 out of 14)	0^0-14.66^0
	Right	4.88	7.1	0% (0 out of 20)	100% (14 out of 14)	0- 19^0
Total	Left	18.64	5.63	0% (0 out of 20)	100% (34 out of 34)	0- 25^0
	Right	19.36	5.5	14.7% (5 out of 34)	85.3% (5 out of 34)	0-29^0

[a]Origin of radial artery is proximal to superior margin of the head of the radius in 7.35%.
*Origin of radial artery is distal to superior margin of the head of the radius in 82.65%.
^Significantly ($P<0.05$) larger than corresponding right side value.

In male, the means and associated standard deviations (mm) of the external and internal diameters of the right radial artery are greater than the left one whereas the thickness mean of the left radial is greater than the right radial artery at its origin. At the wrist, the means and associated standard deviations (mm) of the external and internal diameters of the left radial artery are greater than the right one. In female, the means and associated standard deviations (mm) of the external diameter and the thickness of the right radial artery are greater than the left side whereas the internal diameter mean of the left radial artery is greater than the right radial artery at its origin. At the wrist, the means and associated standard deviations (mm) of the external and internal diameters of the right radial artery are greater than the left one while the thickness of radial artery is equal in both sides. The internal and external diameter of the radial artery at its origin and at the wrist found to be gradually decreased from proximal to distal in both females and males (Table 2).

In total specimens, the means and associated standard deviations (mm) of the internal diameter and thickness of the right radial artery are greater while the external diameter of the left radial artery is greater than the right one at its origin. At wrist, the means and associated standard deviations of the external diameter and thickness of the left radial artery are greater than right one while the internal diameter of the right radial artery is greater than the left one (Table 2). There is also significance($P<0.05$) difference between the male and female values with the males being larger, as well as between right and left side thickness proximally in females.

Table 2: The Means, associated standard deviations (mm) of the external and internal diameters, and thickness of the radial artery at its origin and at the wrist

Radial artery	Side	Mean (SD)		
Male	**Left**	**External**	**Internal**	**Thickness**
	Origin	3.63(0.84)	3.44(0.88)*	0.09(0.02)*
	Wrist	3.62(0.82)*	3.25(0.50)*	0.18(0.16)
	Right	**External**	**Internal**	**Thickness**
	Origin	3.71(0.91)	3.58(0.68)*	0.06(0.11)*
	Wrist	3.59(0.80)*	3.25(0.54)*	0.17(0.13)*
Female	**Left**	**External**	**Internal**	**Thickness**
	Origin	3.20(0.66)	2.90(0.54)	0.15(0.06)**
	Wrist	2.99(0.58)	2.76(0.40)	0.12(0.09)
	Right	**External**	**Internal**	**Thickness**
	Origin	3.25(0.69)	2.87(0.67)	0.19(0.01)
	Wrist	3.04(0.64)	2.80(0.54)	0.12(0.05)
Total	**Left**	**External**	**Internal**	**Thickness**
	Origin	3.45(0.79)	3.22(0.80)	0.12(0.00)
	Wrist	3.36(0.78)	3.05(0.52)	0.16(0.13)
	Right	**External**	**Internal**	**Thickness**
	Origin	3.52(0.85)	3.29(0.75)	0.11(0.05)
	Wrist	3.36(0.78)	3.06(0.58)	0.15(0.10)

*Significantly ($P<0.05$) larger than corresponding female value
**Significantly ($P<0.05$) larger than corresponding right side value

DISCUSSION

During embryonic development of limb, the vascular variation is based on growth or regression of buds plexus. Consequently, any faults in embryonic progress of the buds plexus result in numerous variations in the arterial origins as well as courses. The variability of vascular upper limb ranges between 9% and 18.5% (Ciervo et al; 2001). The variability of radial artery in origin and course is very common which may affect the diagnosis and management as well as surgical interferences. Learning the anatomical vascular variations provide medical implications. Accordingly, it is important for clinicians to realize the thickness, diameter and the variability of the radial artery because of a numeral of surgical and invasive interferences are done in the cubital region. This may lead to reduce iatrogenic mistakes.

In cubital fossa, the radial artery usually arises at the level of neck of radius (Standring ; 2005) in 21.7% howeverit may arise either before or after to the level of neck of radius in 11.7% or in 6% correspondingly (Al-Sowayigh et al; 2013). It usually arises after interchondyler line in 92% (Nasr; 2012) but it may arise before interchondyler line in 10% (Al-Sowayigh et al; 2013). Therefore, the radial artery arises from brachial or axillary artery before the antecubital fossa referred as a high origin. In current study, the radial artery frequently arises distal to superior margin of the head of the radius in 82.65%. However, it infrequently arises from in 7.35% in total cases which found to be more in male and right side (Table 1). Further, of angle degree of radial artery according to brachial artery ranges between to 8^0 to 30^0. This angle found to be wider in male and right side (Table 1).

The mean of the external diameter of the radial artery is 3.3 mm at its origin while it is 3.1 mm at styloid process. This recent study has done by Nasr (2012) describe the external diameter of radial artery at proximal to origin and styloid process without any detail of the internal diameter which could be useful information for the artificial arteriovenous fistula procedure. In current study, the external diameter of the radial artery is 3.48 mm at its origin while it is 3.6 mm at wrist. This study agrees with the earlier research study (Nasr; 2012). The right external diameter is larger than the left one in total specimens as well as in male and female except at the wrist region in male. The external diameter is larger in male than in female (Table 2).

The failure rate of artificial arteriovenous fistula is related to internal diameters radial artery ranging from 1.5 to 2.0 mm (Brimble et al; 2001). The radial artery decreases in size from the proximal to distal part during its course (Yoo et al; 2005). Therefore, this study includes the internal diameter of radial artery at cubital and wrist region. The average of internal diameter of radial artery at its origin is 2.5mm (Chang et al; 1986) whereas the average of the internal diameter of radial artery is 2.3mm at the wrists (Ku et al; 2006). In present study, the average of internal diameter of radial artery at its origin is 3.26mm whereas the average of the internal diameter of radial artery is 3.55mm at the wrists. Therefore, as the radial artery descends the internal diameter decreases in size (Table 2).

According to a review comparison studies of radial artery in both sexes, the internal diameter to be larger in males than female (Huzjan et al; 2004, Yoo et al; 2005; Tariq et al; 2010), they stated that radial artery found. In current study the internal diameter of radial artery found to be larger in male than female which is an agreement with the earlier researches (Table 2). Based on comparison of left and right radial arteries, the mean diameter of left and right radial artery found to be 3.19mm and 3.28mm (Huzjan et al; 2004) and 2.2 mm and 2.3 mm correspondingly (Tariq et al; 2010) whereas it found to be 2.22 mm and 2.29 mm at its origin and equal at the wrist in current study. Therefore, current study agrees with the earlier studies that the right side of radial artery is more prominent than the left.

In male, the mean internal diameter of the left and right radial arteries are 3.28mm and 3.39mm respectively (Huzjan et al; 2004) whereas the left artery and right radial arteries are 3.44mm and 3.58mm at its origin respectively and there is no difference at wrist in this study. Therefore, current study shows the right radial artery is more prominent than the left one in male and disagrees with earlier study (Huzjan et al; 2004). In female, the mean internal diameter of radial artery of the left and right sides are 2.85mm and 2.86mm respectively proximal to the wrist (Huzjan et al; 2004) and it found to be 2.76mm and 2.80 in current study. Therefore, the current study agrees with Huzjan et al (2004) study. Proximal to the styloid process, the internal diameter radial artery is more prominent than the external diameter (Yoo et al; 2005). On the other hand, the external diameter is larger than the internal diameter in current study. The mean of radial artery thickness found to be 0.25mm (Ku et al; 2006) and 0.238mm (Myredal et al; 2009) whereas it found to be 0.115mm at its origin and 0.155mm at wrist level in current study. Therefore, the United Kingdom population has the least thickness of radial artery comparing to Japanese (Ku et al; 2006) and Sweden population (Myredal et al; 2009).

According to series studies, the best vascular access for hemodiaysis is radiocephalic and has a high failure rate. The failure and success rate of artificial arteriorvenous fistula is linked to the internal diameter of radial artery. The failure rate increase as the internal diameter is less than 1.5 mm whereas the success rate increase as it is more than 1.6 mm (Parmar et al; 2007, Kian et al; 2012). Consequently, the radial artery is a proper choice of artificial arteriovenous fistula procedure in high bifurcation of brachial artery cases. Therefore, understanding the morphological characteristics of radial artery results in reduce the iatrogenic faults. Due to size of radial artery, the right side increases the success rate of artificial arteriovenous fistula. Radiologists have to be aware of the both diameters and wall thickness of radial artery to alert the nephrologists and vascular surgeons to increase the success rate of the artificial arteriovenous fistula procedure. This leads to improve outcomes and avoid the iatrogenic errors in diagnosis as well as in medical and surgical treatment. Besides, it may help cardiologists and radiologists in catheterization procedure in coronary and radiology interferences.

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