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Original Research Paper

Anatomy

A STUDY OF RADIAL ARTERY, ITS BRANCHING PATTERN AND VARIATIONS WITH CLINICAL APPLICATIONS

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ABSTRACT **Background:** The radial artery is the smaller terminal branch of the brachial artery. It is one of the most commonly used arteries for various interventions. Anatomical variations exist and can predispose patients to iatrogenic injury if the operator is unaware of normal radial artery morphology. **Aims And Objective:** To study the radial artery course, branching pattern, its variations and clinical applications. **Materials And Methods:** 20 upper limbs of 18 men and 2 women adult cadavers were used in this study. The cadavers were obtained from the Anatomy Department, Madhubani medical college, Madhubani, Bihar. The axillary region, arm, forearm, and hand of each limb were dissected to clarify the course and branches of the radial artery. This anatomical descriptive study was conducted between August 2019 to July 2022 after approval of the Ethical Committee. **Results:** The mean distance of the normal origin of the radial artery as one of two terminal branches of the brachial artery was 36.6 ± 8.5 mm in men and 34.5 ± 7.5 mm in the upper limbs of women below the intercondylar line, and variant origin of the radial artery was found in six limbs. The mean of radial artery length was 218.2 ± 20.7 mm in men and 204.9 ± 11.9 mm in women and that of its external diameter was 3.3 ± 0.6 mm in men and 3.0 ± 0.55 mm in women at 1 cm distal to its origin; 3.0 ± 0.63 mm in men and 2.9 ± 0.65 in women at 2 cm proximal to the styloid process of the radius. The radial artery showed different branching patterns and three modes of termination. **Conclusion:** Knowledge of radial artery description and its variants has great importance in different clinical fields and basic medical studies.

KEYWORDS : Radial artery, branches, variations and cadaver

INTRODUCTION:

Variations in the origin, branching pattern and course of the arteries of upper limb have received the attention of anatomists, cardiologists and vascular surgeons. The radial artery (RA) is the smaller of the two terminal branches of the brachial artery (BA) in the cubital fossa, medial to the biceps tendon. It ascends from the BA in the cubital fossa approximately 1.0 cm below the bend of the elbow opposite the neck of the radius and is a more direct continuation of the BA. After its origin it traverses through the lateral aspect of the forearm approaching its lower end where it enters the palm to anastomose with the deep branch of the ulnar artery to complete the formation of the deep palmar arch. The proximal RA courses underneath the muscle belly of the brachioradialis muscle, and its middle part lies near the superficial branch of the radial nerve. The distal third of the RA becomes superficial and is positioned anterior to the radius and pronator quadratus muscle between the tendons of the brachioradialis and flexor carpi radialis [1]. The anatomical variations of the upper limb arterial pattern are common and have been previously reported by several investigators [2, 3]. Diversions of the RA from its normal anatomical pattern as regards its origin or its course constitute the largest group of vascular variations of the upper limbs [4].

Such variations may interfere with diagnostic, therapeutic, and surgical interventions [5]. Variations in the origin, branching pattern and course of the arteries of upper limb have received the attention of anatomists, cardiologists and vascular surgeons. Radial artery starts 1 cm distal to the flexor crease of elbow as a small terminal branch of brachial artery in the cubital fossa at the level of neck of radius. Direction of radial artery appears to be a direct continuation of parent trunk. It extends from the cubital fossa to the palm and ends by anastomosing with the ulnar artery to form deep palmar arch [6, 7]. New interest in RA anatomy is being generated due to the increased use in different coronary interventions. The ease of access, high success rate, ease of care for nursing staff, given rich collateral circulation of the human hand, and low risk of thrombosis are the reasons for the popularity of the RA. These anatomic features of the RA are the main determinants for the feasibility of using it as a route for coronary intervention [8]. Moreover, in this condition, the RA had close proximity to the cephalic vein that might produce dangerous complications during the intravenous injection of medications [9]. The variant high origin of the RA, defined as RA arising either from the brachial or axillary artery (AA) proximal to the antecubital fossa, has been found in 2.4% to 14.3% of upper extremities [8, 10]. Opposite origin of the radial and ulnar arteries to the usual arrangement, defined as the origin of the RA from the medial and of the ulnar artery from the lateral side of the brachial artery, has been rarely reported [11].

EMBRYOLOGY:

By the end of 4th week, the limb buds develop as outpouchings from the ventrolateral aspect of body wall. From the dorsal aortae, number of small branches arise and reach the developing limb bud to form a primitive capillary plexus. Only one trunk which has the position and relation of the 7th intersegmental artery persists to form the axis artery of upper limb. This trunk later develops into subclavian, axillary, brachial and anterior interosseous artery and terminates in the developing hand as deep palmar plexus.

AIMS AND OBJECTIVE:

To study the radial artery the course, branching pattern, its variations with clinical applications.

MATERIAL AND METHODS:

20 adult human cadavers (18 males and 2 females) were used in this study. The specimens were obtained from the Anatomy Department, Madhubani Medical College, Madhubani, Bihar from August 2019 to July 2022. The cadavers were placed in a supine position and their upper limbs were abducted to 90° to straighten their arteries and extend their elbow and wrist joints. The right and left upper limbs of each cadaver were dissected from the axillary region down to the hand including the arm, cubital fossa, forearm, and the anatomical snuffbox. The skin and fasciae of the dissected regions were incised and

reflected to expose the deep structures. Both pectoralis major and minor muscles were dissected from their origins and reflected on the lateral side to expose the axillary vessels and branches of the brachial plexus. The biceps muscle was retracted laterally to follow the course and branching pattern of the axillary and brachial arteries and their surrounding nerves. The brachioradialis muscle was displaced laterally to facilitate the handling, mobilisation, and dissection of RA within the forearm. The anatomical snuffbox was dissected to expose the RA down to the first dorsal interosseous space. The course and the branches of the RA in the forearm and hand were carefully dissected; their morphology and variations were recorded. The flowing parameters of RA were measured in both right and left limbs of each cadaver. (1) Its original level in relation to the interepicondylar line of the humerus, (2) its length in correlation with the forearm length, and (3) its external diameter at 1 cm distal to its origin and at 2 cm proximal to the styloid process of the radius. In addition, any variant of its course and distribution and its branching patterns within the forearm and hand and modes of termination were measured. The measurements were taken using a Vernier calliper (0.01 mm accuracy) and measuring strap (Fig. 1). All data were tabulated regarding sex and side of the limb.

METHOD OF STUDY:

Conventional dissection method.

SPECIMEN COLLECTION:

Adult upper limb specimens were obtained from the embalmed cadavers allotted for routine academic dissection to the first year MBBS students between August 2019 to July 2022 at the Institute of Madhubani Medical College, Madhubani, Bihar in the department of Anatomy after getting the ethical clearance from the ethical committee.

CONVENTIONAL DISSECTION METHOD

A horizontal incision was made in arm at the junction of the upper 1/3 and middle 1/3. A vertical incision was made from the middle of cubital fossa to the wrist extending over the palm up to the tip of middle finger. This incision was extended upwards meeting the first horizontal incision. Another horizontal incision was made at the level of wrist and the skin flap was raised medially and laterally. An oblique incision was made on the palm extending from the vertical incision to the thumb. 20 Another horizontal incision was made in the palm at the level of base of metacarpals and the skin flaps were raised. Present study was done to document and provide information of both normal and variant morphology of the radial artery.

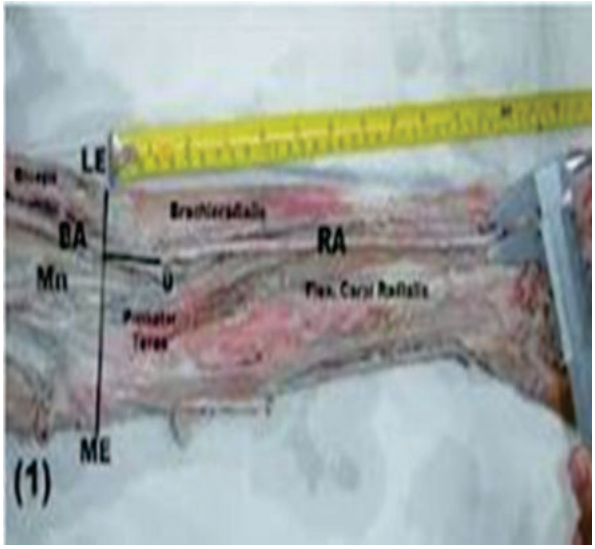

Figure 1. Light photograph of a left female upper limb

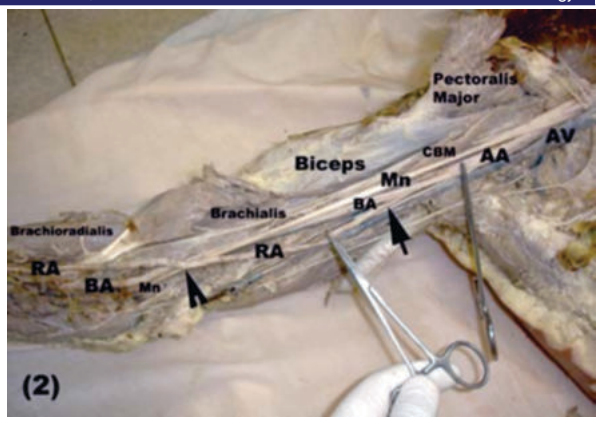

Figure 2. Light photograph of a right female upper limb showing the abnormal high-origin (black arrow) radial artery (RA) crossing (open arrow head) the median nerve (Mn) and brachial artery superficially

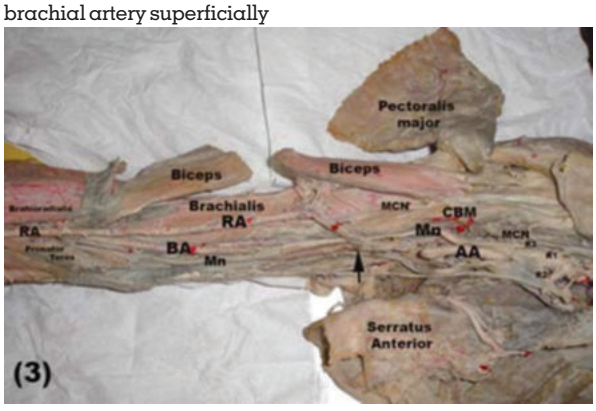

Figure 3. Light photograph of a right male upper limb showing the radial artery (RA) originating from the lateral aspect of the upper part of the brachial artery (BA).

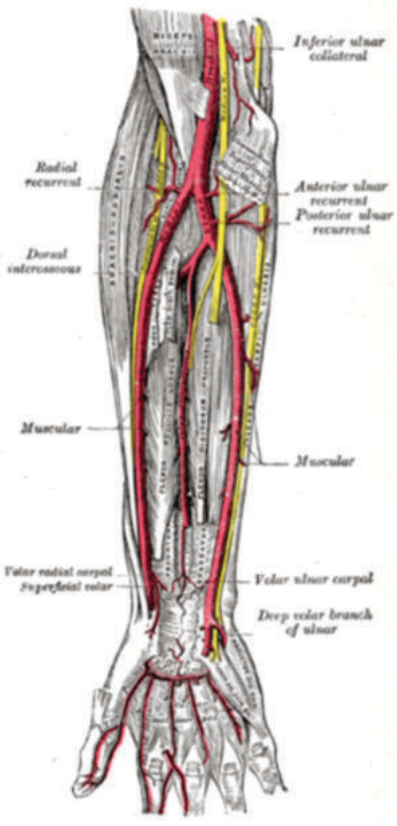

Fig: 4 -

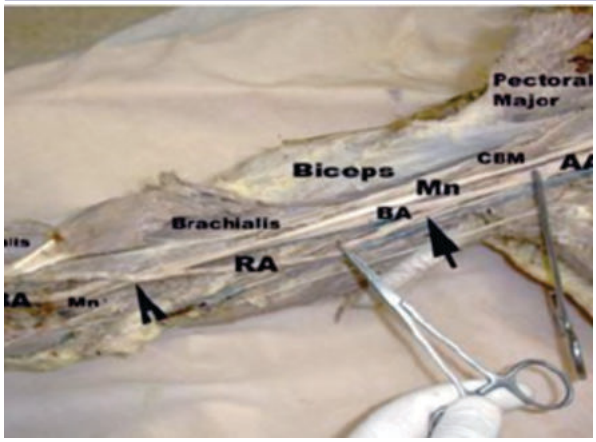

Fig: 5- Light photograph of a right female upper limb showing the abnormal high-origin (black arrow) radial artery (RA) crossing (open arrow head) the median nerve (Mn) and brachial artery superficially.

Inclusion Criteria:
All twenty adult human cadavers 18 males and 2 females.

Exclusion Criteria:
Any limb with discontinued RA, fractured bone, burn and previous dissection was discarded.

Statistical Analysis:
It was performed using SPSS 16.0. All measurements were expressed as mean ± SD. Continuous variables were compared using Student's t-test. A p value of < 0.05 was considered statistically significant.

RESULTS:

The mean distance of the normal origin of the radial artery as one of two terminal branches of the brachial artery was 36.6 ± 8.5 mm in men and 34.5 ± 7.5 mm in the upper limbs of women below the intercondylar line, and variant origin of the radial artery was found in six limbs. The mean of radial artery length was 218.2 ± 20.7 mm in men and 204.9 ± 11.9 mm in women and that of its external diameter was 3.3 ± 0.6 mm in men and 3.0 ± 0.55 mm in women at 1 cm distal to its origin; 3.0 ± 0.63 mm in men and 2.9 ± 0.65 in women at 2 cm proximal to the styloid process of the radius. The radial artery showed different branching patterns and three modes of termination.

DISCUSSION:

The pattern and rate of the abnormal RA were different from one race to another; the axillary origin of the RA was seen in 5% of African people while it was seen in 2.7% of the Caucasian population [12]. The incidence range of the high origin RA from the BA varied from 5.9% to 12.1% among Caucasians but it was observed in 2.3% of 304 Korean cadavers [13]. However, its prevalence was 0.33% among Singaporean Chinese Cadavers [14]. The racial difference of the existence of abnormal origin of the radial had no clear explanation. Such abnormal origins of the RA might be the cause of failure of the transradial approach during surgical or radiological interventions. Thus, this variation must be kept in mind during any vascular, reconstructive, cardiac, orthopaedic, or radiological manipulations. The abnormal course of the RA is of interest to clinicians, particularly surgeons and radiologists. The abnormal high-origin RA had a variant relation within the arm especially to the median nerve and the BA and to a lesser extent to the biceps and brachialis muscles. In agreement with the results of the present study, Natsis et al. [15] found high-origin RA with different courses within the arm, the RA originated from the medial side of the BA above the intercondylar line. These arteries descended in front of the median nerve at the cubital fossa and crossed it anteriorly below the intercondylar line to pass within the front of the forearm in its normal anatomical course [16]. However, an unusual course of the RA was observed by Pelin et al. [17], who stated that the RA originated from the medial aspect of the upper part of the BA crossing the median nerve twice: once at its original level and secondly in the cubital fossa. Thereafter, the RA descended in its normal anatomical course within the front of the forearm. Similarly, a case of high origin of RA with double crossing the median nerve within the arm was observed [18]. The abnormal course of the RA was not only observed in the arm but also within the anatomical snuffbox as well. Moreover, Patnaik et al. [19] found the RA at the base of the 2nd metacarpal where it turned distally to pass through the 2nd intermetacarpal space between the 2 heads of the 2nd dorsal interosseous muscle. Such anomalies were not observed in the present study. In agreement with the case of the abnormal RA of axillary origin of the present study, RA coursing behind the biceps brachii tendon was observed [20].

In the present study, the RA crossed the median nerve and BA superficially deep to the brachialis and biceps muscles at the front of the elbow joint. The presence of such a superficial RA showed close proximity to the cephalic vein, which might produce dangerous complications during the intravenous injection of medications and might interfere with the palpation of the normal radial pulse at the wrist with production of cannulation failure [21]. Moreover, in this condition, the RA had close proximity to the cephalic vein that might produce dangerous complications during the intravenous injection of medications [22]. The anomalies of the RA might be due to the persistence of its proximal segment with production of high origin [23]. Although knowledge of the exact factors responsible for each arterial variation is impossible, many changes may occur due to changes in the haemodynamic forces, foetal position within the uterus, genetic predisposition, chemical factors, and developmental arrest at any stage [15, 24]. In the present study, the RA normally originated as one of two terminal branches of the BA The mean distance of the normal origin of the radial artery as one of two terminal branches of the brachial artery was 36.6 ± 8.5 mm in men and 34.5 ± 7.5 mm in the upper limbs of women below the intercondylar line, and variant origin of the radial artery was found in six limbs. The mean of radial artery length was 218.2 ± 20.7 mm in men and 204.9 ± 11.9 mm in women and that of its external diameter was 3.3 ± 0.6 mm in men and 3.0 ± 0.55 mm in women at 1 cm distal to its origin; 3.0 ± 0.63 mm in men and 2.9 ± 0.65 in women at 2 cm proximal to the styloid process of the radius [19]. Meanwhile, the RA began about 1 cm below the bend of the elbow at the level of the neck of the radius [25]. However, abnormal branching pattern was found in 9% [26] and in 3.2% [27] of the specimens. The discrepancy of this distance might be due to racial difference or the number of specimens. Knowledge of the different branching patterns of upper limb arteries has clinical and surgical significance. The branching pattern of the RA and its variations has been rarely studied [28]. In the present study, the radial recurrent artery originated from the RA in 83.3% of male and 82.5% of female specimens and from the BA in 15% the specimens. Meanwhile, it was absent in 2% of the specimens. In disagreement with the results of the present study, the radial recurrent artery was a branch of the BA in 12% of the specimens [16]. Moreover, the palmar carpal artery was absent in 26.7% [16] of cases, while it was absent in 22.5% of the specimens of the present study. Conversely, the absence of the first dorsal metacarpal was (12%) more than that seen by Gupta et al. [16], who reported that the first dorsal metacarpal artery was absent in 9.3% of specimens. The differences between the results of these 2 studies might be related to the number of specimens used in each.

CONCLUSION:

Knowledge of radial artery description and its variants has

great importance in different clinical fields and basic medical studies. Knowledge of normal and variant RA distribution and parameters provide surgeons and radiologists with the ability to make proper decisions that achieve better preoperative evaluation, surgical and radiological interventions, and good postoperative results.

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