



## AN OBSERVATIONAL STUDY ON VARIATIONS IN THE ARTERIAL PATTERN OF THE UPPER LIMB, ITS EMBRYOLOGICAL BASIS AND CLINICAL SIGNIFICANCE

### Anatomy

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### ABSTRACT

**Introduction:** The arterial pattern of adult human upper limb shows a large number of variations. Embryological basis of these arterial variations found in the arm and forearm arteries can be explained by persistence of the superficial embryonic vessels in adults. **Methods:** The present study was done in 30 cadavers in the department of anatomy, K.P.C. Medical College, Kolkata to find out variations in the arterial pattern of the upper limb. **Observation And Results:** The superficial brachial artery that passes superficial to the median nerve was present in 5% cases. The brachioradial artery (high origin of radial artery) was present in 6.67% cases. The brachioradial artery took origin from axillary artery in 1 specimen, from upper third of brachial artery in 2 specimens and from middle third of brachial artery in 1 specimen. The brachioulnar artery (high origin of ulnar artery) was observed only in 1 specimen (1.67%) on the left side. The superficial ulnar artery was present in 1 specimen (1.67%) and that was on the right side. **Conclusion:** The information of patterns and incidence of these arterial variations are especially important for clinicians and surgeons performing invasive procedures to a particular area of arm and forearm.

### KEYWORDS

Arterial variations, Brachial artery, Arm, Forearm

### INTRODUCTION

Variation in the arterial pattern of the upper limb is not very uncommon and was subject to many studies due to their high incidence. However, there is much confusion due to the use of different terminologies, and of different criteria for classifying and or sub-classifying them. Some authors used a topographical criteria to name the arteries in the arm and rename the arteries once it crossed the elbow based on its course<sup>1,2,3</sup>, thereby variations in the arm and forearm arteries were analysed separately producing an overlapping results and omitting some important data regarding its continuation or origin. To simplify and unify the criteria subsequent authors considered the variant artery as a complete entity in the arm and forearm and maintaining the same name in the arm and forearm<sup>4</sup>.

Using proper terminology, unifying the topographical criteria, considering the arterial variation as a complete entity throughout its course, following types of variations can be found in the arm and forearm arteries.

1. Variations found exclusively in the arm :

**(i) Superficial brachial artery** is a brachial artery which passes in front of rather than behind the median nerve, but it does not present any further deviation from normal and at elbow it branches into forearm arteries.

**(ii) Accessory brachial artery** – when a second brachial artery is present which originates from the brachial or axillary arteries and rejoins the brachial artery proximal to the elbow before dividing into usual forearm arteries.

2. Variations found along the arm and forearm –

**(i) Brachioradial, (ii) brachioulnar, (iii) brachiointerosseous, (iv) brachio median and (v) brachioulnoradial arteries** – the arteries taking origin in the arm and continue as either radial, ulnar, interosseous, median or radial and ulnar arteries respectively in the forearm. The term superficial is added, if it courses in the superficial fascia.

3. Variations found exclusively in the forearm –

**(i) Superficial radial artery** – radial artery with a normal origin coursing over the tendons defining the anatomical snuffbox.

**(ii) superficial ulnar artery** – ulnar artery with a normal origin courses over the superficial forearm flexor muscles.

**(iii) Superficial median artery** – courses superficial to the forearm

flexor muscles.

**(iv) Palmar pattern of median artery** – reaching the palm to supply fingers instead of ending in the forearm.

**(v) Absence of radial artery**

**(vi) Absence of ulnar artery**

**(vii) Duplication of radial or ulnar artery or both**

The knowledge of variations of arterial pattern of upper limb is important for clinicians and surgeons performing invasive procedures in the arm and forearm. Variations in the arteries of this region may be encountered during angiography, percutaneous catheterization and skin flap elevations from the arm or forearm. The superficial brachioradial and superficial brachioulnar arteries have been encountered during elevation of the radial forearm flap for intraoral reconstruction<sup>5,6,7</sup>. The superficial brachioulnar artery has been suggested as a basis for skin flap<sup>8</sup>. Accidental intra-arterial injection of drugs due to close proximity to normal venipuncture site has been reported which may lead to bleeding, thrombosis or even loss of the upper limb. Misinterpretation of arteriographic results has also been reported when contrast dye is injected distal to the origin of variant arteries<sup>9,10,11</sup>. There is absence of normal radial pulse at wrist level in case of superficial radial artery<sup>12,13</sup> which also produces problems during cannulation. Absence of ulnar artery may cause hand ischaemia after radial artery grafting for coronary bypass<sup>14</sup>.

### MATERIALS AND METHODS

The present study was done in 30 (24 males and 6 females) formalin preserved cadavers in the department of anatomy, K.P.C. Medical College and Hospital, Kolkata to observe the variations in the arterial pattern of the upper limb. The upper limbs of both sides were dissected following the steps described in Cunningham's manual of practical anatomy. Traumatized or deformed upper limbs with any pathological lesion or surgical procedures were excluded from the study. An incision was made in the upper limb from axilla to wrist. The skin & fascia were exposed in layers. The arteries of the arm and forearm were traced carefully from its origin to termination. The findings were appropriately documented and photographed.

### RESULTS

The following types of variations were observed in the present study. Out of 60 upper limbs dissected, the superficial brachial artery (**Figure 1**) that passes superficial to the median nerve was present in 3 specimens (5%) among which 2 was on the right side and one on the left side (**Table 1**). The brachioradial artery (high origin of radial

artery) was present in 4 specimens (6.67%) out of which 3 were on the right side and 1 was on the left side (Table 2). The brachioradial artery took origin from axillary artery in 1 specimen (Figure 2), from upper third of brachial artery (Figure 3) in 2 specimens and from middle third of brachial artery in 1 specimen. The brachioulnar artery (high origin of ulnar artery) was observed (Figure 4) only in 1 specimen (1.67%) and that was on the left side (Table 3). The superficial ulnar artery (Figure 5) was present in 1 specimen (1.67%) which was on the right side (Table 4).

**Table 1: Course Of Brachial Artery**

| Course                      | Right (n=30) | Left (n=30) | Total (n=60) |
|-----------------------------|--------------|-------------|--------------|
| Normal                      | 28 (93.33%)  | 29 (96.67%) | 57 (95%)     |
| Superficial brachial artery | 2 (6.67%)    | 1 (3.33%)   | 5%           |

**Table 2: Incidence Of Brachioradial Artery**

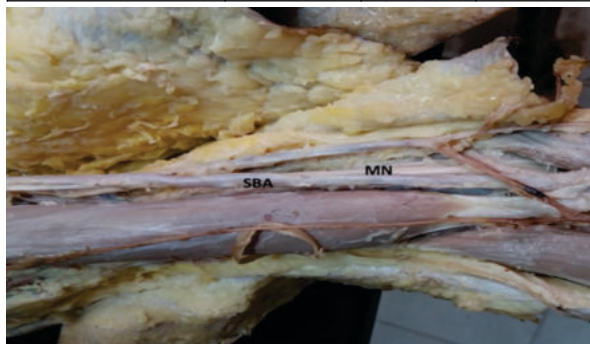
| Brachioradial artery        | Right (n=30) | Left (n=30) | Total (n=60) |
|-----------------------------|--------------|-------------|--------------|
| Origin from axillary artery | 0            | 1           | 1 (1.67%)    |
| Origin from brachial artery | 2            | 1           | 3 (5%)       |

**Table 3: Incidence Of Brachioulnar Artery**

| Incidence           | Right (n=30) | Left (n=30) | Total (n=60) |
|---------------------|--------------|-------------|--------------|
| Brachioulnar artery | 0 (0%)       | 1 (3.33%)   | 1 (1.67%)    |

**Table 4: Incidence Of Superficial Ulnar Artery**

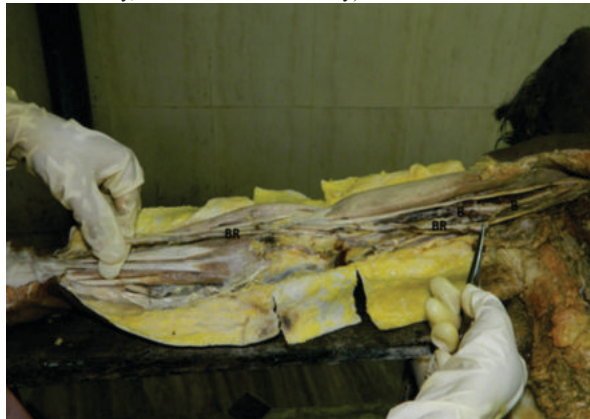
| Incidence                | Right (n=30) | Left (n=30) | Total (n=60) |
|--------------------------|--------------|-------------|--------------|
| Superficial ulnar artery | 1 (3.33%)    | 0 (0%)      | 1 (1.67%)    |



**Figure 1: Superficial Brachial Artery (SBA – Superficial Brachial Artery, MN – Median nerve)**



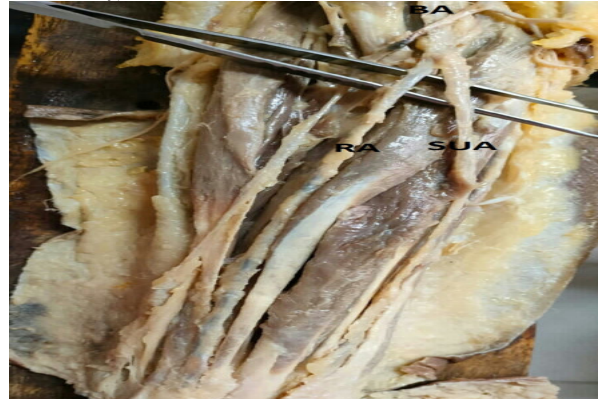
**Figure 2: Origin Of Brachioradial Artery From Axillary Artery (BA – Brachial artery, BR – Brachioradial artery)**



**Figure 3: Origin Of Brachioradial Artery From Brachial Artery (BR – Brachioradial artery, B – Brachial artery)**



**Figure 4: Brachioulnar Artery (BUA – Brachioulnar artery, RA – Radial artery)**



**Figure 5: Superficial Ulnar Artery (RA – Radial artery, SUA – Superficial ulnar artery)**

## DISCUSSION

Variation in the arterial pattern of upper limb was reported for the first time by Von Haller in 1813<sup>15</sup>. McCormack et al<sup>4</sup> dissected 750 cadavers and noticed variations of upper limb arteries in respect to origin and course in 18.53% cases. In the present study, variations was observed in 15% cases.

Among these variations, the superficial brachial artery was present in 5% cases in our study. The incidence of superficial brachial artery observed by previous researchers varies from 3.6% to 9.6%<sup>15,16,17</sup>. Fuss et al.<sup>17</sup> described that the superficial brachial artery usually adopts a superficial course above the median nerve roots, while the other studies<sup>18</sup> and the present study showed the superficial course below these level more frequently. After adopting its superficial course, the superficial brachial artery does not present any further deviation from the normal.

Accessory brachial artery, another type of variation found in the arm, incidence of which was reported by previous researchers in about 0.26% upper limbs<sup>18</sup> was absent in our study.

Brachioradial artery, defined as high origin of the radial artery coexisting with a brachial or superficial brachial artery that branches into ulnar and common interosseous trunk was found in 6.67% cases in the present study, among which 75% cases (3 specimen) took origin from brachial artery and 25% cases from axillary artery. The brachioradial artery after its origin, crossed the median nerve and adopted a superficial position to it along the arm, while the brachial artery was in its normal position behind the median nerve. Incidence of brachioradial artery reported by Rodriguez et al.<sup>18</sup> was 13.8%, by McCormack et al.<sup>14</sup> in 14.27% of upper limbs which is quite higher than our findings. Findings of Padma Verlekaret al.<sup>19</sup> (6.25%) Subhash M Gujaret al.<sup>20</sup> (6%) is similar to our findings. The present study confirms the earlier studies, that the brachioradial artery takes origin more frequently from the brachial artery than the axillary artery<sup>14,18</sup>.

Occurrence of brachioulnar artery is less frequent than the other types of variations. In the present study, the brachioulnar artery, defined as ulnar artery with a high origin and a normal course along the forearm and hand was found only in one cadaver (1.67%) on right side and its origin was from middle third of the brachial artery. Incidence of brachioulnar artery was reported by Rodriguez-Niedenfuhr et al. in

0.26% cases and its origin was from axillary artery, while others found it to take origin from brachial artery<sup>21,22</sup>.

Superficial ulnar artery which courses sub-fascially over the superficial flexor muscles of the forearm was found in one male cadaver (1.67%) in the present study. The existence of superficial ulnar artery has been reported by various investigators. Weathersby<sup>23</sup> dissected 451 upper limbs and found 3 cases of superficial ulnar artery (0.6%). Quain<sup>24</sup> found 29 cases in 442 upper limbs; Rodriguez-Baeza<sup>21</sup> et al. found 8 cases in 151 upper limbs (5.3%) and Nakatani et al.<sup>25</sup> found occurrence of superficial ulnar artery in 0.7% cases.

The current theory regarding the development of the vascular system of the upper limb states that it begins at stage 12 (3-5 mm ; 26 d). Initially a capillary plexus enters the limb bud and extends from proximal to distal direction as the limb grows. In later stages the axial artery is differentiated which represents the axillary, brachial and anterior interosseous arteries. The forearm arteries arise successively by angiogenic sprouting : the median artery develops first, followed by ulnar and finally the radial arteries<sup>25,26,27</sup>.

According to earlier embryologists, the capillary network was composed of superficial and deep pathways anastomosing at different levels<sup>28</sup>.

By stage 17(11.14mm; 41 d) differentiation process reaches the elbow region, and a well developed brachial artery can be found upto the elbow level<sup>29</sup>.

The superficial brachial artery, a consistence embryonic vessel, identified in the 11.7mm crown rump length(CRL) embryo by Muller<sup>30</sup> and in 21mm CRL embryo by Senior<sup>30</sup> joined the axillary and brachial segments of axial artery at several places.

The superficial brachial artery plays an important role in the arterial morphogenesis of the upper limb. Persistence of this artery in the adult , coexisting or not with the brachial artery was found by various researchers<sup>17,25, 31</sup>. The superficial brachial artery has two terminal branches : a medial one, the superficial antebrachial artery and a lateral one that continues in the forearm as a part of the definitive radial artery. The superficial antebrachial artery divides into two terminal branches : median and ulnar<sup>28,31</sup>. Each of these branches anastomoses with a corresponding branch of primitive axial artery. Gradually the trunks of deep origin obtain a haemodynamic predominance and the superficial antebrachial artery together with the preanastomotic segment of its terminal branches regress<sup>32</sup>.

The lateral terminal branch of superficial brachial artery anastomoses with the primitive axial artery. The anastomotic trunk forms deep origin of the radial artery. Regression of the superficial arterial segment proximal to the anastomosis occurs and distal segment persists as the distal part of radial artery<sup>21</sup>.

Persistence of these superficial embryonic vessels in adults are responsible for different arterial variations found in adults. Persistence of the superficial artery at brachial level produces two brachial arteries : one superficial and the other deep to the median nerve. When the superficial brachial artery anastomoses with upper third of the radial artery and both the superficial brachial artery and the pre-anastomotic segment of its lateral terminal branch persist that causes high origin of radial artery. Persistence of superficial arteries at both brachial and antebrachial levels in adults produces a brachial or axillary origin for radial and or ulnar arteries. The high origin of radial or ulnar arteries can be embryologically explained by a crossed haemodynamic predominance between superficial and deep arterial territories of the primitive original segments of these arteries which leads to the persistence of the superficial brachial artery and one of its terminal branches and regression of the trunk of deep origin.

## CONCLUSION:

The present study showed different types of variations in the arterial pattern of brachio-antebrachial arteries . The information of patterns and incidence of these arterial variations are especially important for clinicians and surgeons performing invasive procedures to a particular area of arm and forearm . The arterial variations of the upper limb have been implicated in different clinical situations. The superficial brachioradial and superficial brachioulnar arteries have been encountered during elevation of the radial forearm flap. In recent

advances the radial artery is used in reconstructive micro vascular surgeries and also in plastic surgeries. The Chinese forearm flap based on the radial artery is extremely versatile. The radial forearm flap is ideal for intra-oral reconstruction to replace oral mucosa.

Furthermore, the superficial brachioulnar artery has also been suggested as a basis for a skin flap. Possible intra-arterial injection of drugs due to the proximity of normal vein puncture sites , as well as possible arteriographic misinterpretations when the contrast dye is injected distal to the origin of these variant arteries have been reported. The existence of a superficial radial artery produces absence of the normal radial pulse at wrist. It has also been reported as producing problems in cannulation for operation monitoring .

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