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# Sonographic and Cadaveric Study of High-Origin Radial Artery

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## ABSTRACT

**Background:** The radial artery usually branches from the brachial artery near the neck of the radius in the distal antecubital fossa. However, anatomical variations are common, with high-origin radial arteries reported in 0.5–14.27% of cases. **Objective:** The purpose of this study was to investigate the prevalence of high-originating radial arteries (HORA) in vivo via ultrasound in living subjects and through cadaveric dissections. **Study Design:** Case control study. **Settings:** Northumbria University's St. George's International School of Medicine (UK), RLMC Lahore, FJMU Lahore Pakistan. **Duration:** Two and a half years from 2019-2022. **Methods:** Using GE LOGIQ e and SonoSite MicroMaxx ultrasound equipment with 12L-RS & A L38e 10-5MHz transducer, respectively, 300 upper limbs on both sides of 150 persons were investigated. The radial artery was located, followed by a proximal and distal trace to its origin, noting its course and relationships with other anatomical structures. This variance was examined in 95 cadaveric limbs using a standard dissection procedure. **Results:** HORA was found in 23/300 upper limbs. In the participants studied, the HORA were found to occur unilaterally, predominantly on the left side (15/23 cases). **Conclusion:** For radiologists, anatomists, and surgeons, variations in the radial artery's anatomical route and relationships are significant. The presence of HORA affects cardiac catheterization and artery grafting therapies both surgically and clinically. Its narrow course makes it more prone to injury during medication delivery and cannulation, as well as trauma. Bedside ultrasonography techniques can be useful for both identifying before such interventions and for future anatomical analysis.

***Keywords:*** *High originating radial artery (HORA), Cadaveric, Sonographic.*

## INTRODUCTION

Swiss anatomist Albrecht von Haller mentioned changes in the upper limb's arteries in the 19th century during his exploration work, "Anatomical description of the arteries of the human body".[1] These arterial variations are a focus among researchers around the world. Renowned Irish surgeon Richard Quain contributed a great deal of work describing the upper limb's vascular supply, its variability, and its importance during surgery.[2] Variations in the arterial system have been a challenge for doctors during various clinical procedures, such as coronary angiography and trans-radial cardiac catheterization, which have an impact on patient outcomes with the final prognosis.[3-7]

The axillary artery, which starts at the inferior border of the teres major and ends below the level of the elbow before splitting into the radial and ulnar arteries, continues into the upper limb.[8,9] Only skin and fascia cover the brachial artery as it courses along the anteromedial side of the arm. In relation, the brachial artery lies medial to the median nerve in the proximal arm. In the midline of the arm, the median nerve crosses the brachial artery and settles medially at the cubital fossa.[10]

In the literature, brachial artery variations are frequently described. Rodriguez-Niedenfuhr. classified the variety of patterns of arterial variation of the major arteries of the upper limb into 7 types after a meticulous study of 192 specimens.[4] Superior division of the brachial artery was noted along with its division into ulnar and radial artery, proximal to the cubital fossa.[11,12] Thus normal brachial artery was absent.[5,13-16] Proximal to the antecubital fossa. Several case reports have provided details of anatomical variations.[17] without any statistically significant data. Research studies that have used larger samples are successful in providing the prevalence of arterial variations. However, almost all these studies lack anatomical details.

The nomenclature of arterial variations has been a challenge among anatomists and researchers.[18,19] In the literature, authors have provided nomenclature according to their location in the upper limb, viz, (brachial, radial, ulnar, or brachioradial). The names are assigned to the anomalous artery based on its path through different regions. For example, the brachial artery was renamed as radial, ulnar, superficial ulnar, or interosseous as it crossed the elbow. Arteries are also named using Barkow criteria, which unify the topographical features and consider the arterial anomaly as an independent entity throughout the variation course (Figure 1). There is a need to have a mutual agreement between clinical anatomists and surgeons to decide the correct nomenclature for anomalous arteries of the upper limb, and this can avoid inaccuracies in knowledge, which ultimately has its significance in clinical practice.

The anterior origin of the radial artery, sometimes referred to as the higher origination radial artery, is one of the most common arterial variants in the upper arm.[18,20] Radial artery with a high origin was found in a 55-year- old male standardized patient, during a planned session of ultrasound in anatomy for medical students at St. George's International School of Medicine. Detailed analysis of this anomalous artery was performed, and a more extensive study was designed to investigate the prevalence of HORA in different populations in vivo, through the use of ultrasound. The study was expanded to include the population from Pakistan, and the combined data of the UK and Pakistan were analyzed.

This study was designed to explore the frequency of high-originating radial arteries (HORA) in vivo via ultrasound in living subjects and through cadaveric dissections.

## METHODS

This was a case-control study conducted at St. George's International School of Medicine, Northumbria University (UK), Rashid Latif Medical College, Lahore and Fatima Jinnah Medical University Lahore Pakistan. Duration of the study was two and a half years from 2019-2022.

For Ultrasonography: 150 Healthy volunteers (75 males and 75 females) and Cadavers: 95 is sample size.

The study was approved by the Institutional Review Boards of St. George's International School of Medicine, Northumbria University (UK), through the Ethics Review Committee via Letter No. 48.ERC/SGU/2019-20/380, dated 19-07-2020. 150 healthy individuals (75 males and 75 females) were chosen for the study. The volunteers' ages ranged from 19 to 80. All 150 participants (300 upper limbs) had upper limb ultrasound scans performed with GE LOGIC E and SONOSITE MICROMAXX ultrasound equipment equipped with 12L-RS and AL38e 10-5 MHz transducers, respectively. Following informed written consent, two well-trained independent doctors performed ultrasound scans on participants' arms while they sat comfortably.

At the start, a transducer was placed in the antecubital fossa to get a cross-sectional image of the brachial artery, bifurcation, and the radial and ulnar arteries. The artery was traced proximally in the arm to identify any branches. The brachial artery was traced proximally in the arm to find any branches in participants whose bifurcation was not found below the level of the cubital fossa.

After locating branches of the brachial artery in the upper 3rd of the arm and identifying possible HORA, the anomalous artery was confirmed by following it distally into the forearm up to the level of the anatomical snuffbox. Ultrasound images were recorded at three positions: Upper third of the arm (Position I), Antecubital fossa (Position II), and Distal forearm (Position III) as can be seen in Figure 1. Associated neurovascular anomalies were also assessed. The course and presence or absence of arterial anastomosis were also examined.

In addition to ultrasound scans, cadaveric dissection was done in the Anatomy dissection hall of Fatima Jinnah Medical University, Lahore. 95 dissected upper limbs were examined for arterial variations. HORA was seen in 2 of the upper limbs.

## RESULTS

In all 150 participants, the radial artery was found below the antecubital fossa, as an anechoic structure at the lateral side of the forearm. HORA was found in 23/300 upper limbs (7 males and 16 females), predominantly unilateral and on the left side (15/23). The prevalence of 7.6% was noted, which was plotted with different prevalences found in various studies in the literature (Table 1). HORA was found to have a superficial course in the upper arm (Figure 1), in the antecubital fossa,

placing itself closer to the median nerve (Figure 2). In the forearm, HORA was accompanied by the radial nerve superficial branch (Figure 3).

**Figure 1: Position I/Upper third of the arm: A transverse/short-axis ultrasound picture demonstrates the medial and laterally oriented branches that the brachial artery (BA) produces. The arteries are superficial to the median nerve (MN)**

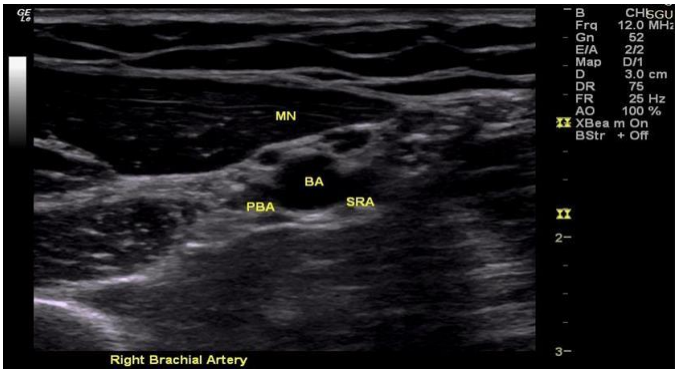



**Figure 2: Position II/ Antecubital fossa: ultrasound picture acquired distal to the bi-epicondylar line using transverse/short-axis scanning. The brachial artery seems to extend deep to the superficial radial artery (SRA) and laterally to the median nerve (MN) as the ulnar artery (UA)**

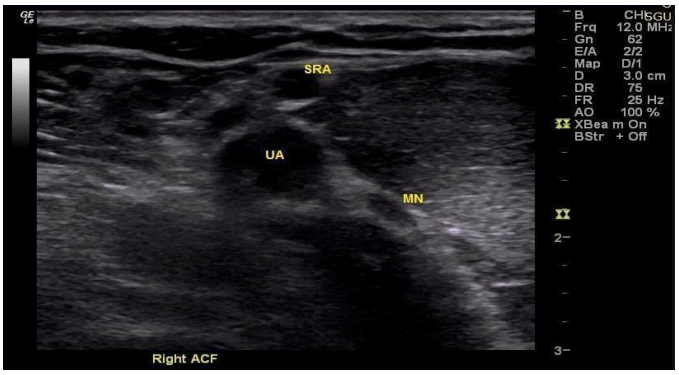
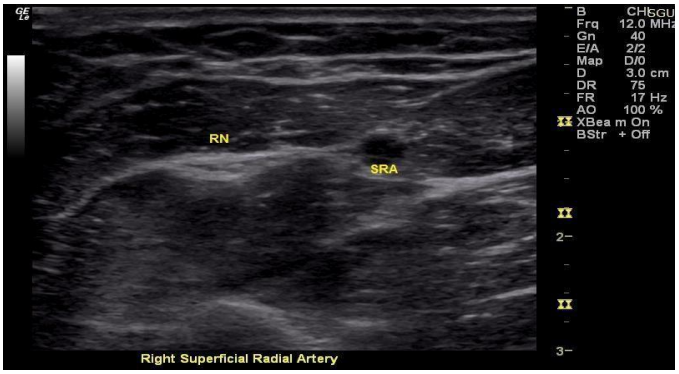



**Figure 3: Position III/Distal forearm: This transverse/short-axis ultrasound image shows the superficial branch of radial artery (SRA) medial and next to the radial nerve (RN)**




The remaining majority originates in the cubital fossa as one of the two terminal branches of the brachial artery. It runs distally on the anterior part of the forearm. There were no associated neurovascular anomalies. Furthermore, there was no vascular anastomosis with other vascular components. In all participants, the ulnar artery was found at the medial side of the forearm below the antecubital fossa. It courses deeper to the radial artery, related to the common interosseous artery.

95 dissected cadaveric limbs were studied for this variation; HORA was seen in 2 of these cadaveric limbs (1.9%).

## DISCUSSION

Despite being the most common arterial variation in the upper limb, cadaveric and angiographic investigations have found varying incidences and prevalences of HORA.

Literature has described its prevalence to range between 4%-15.6, 14.3%. (Table 1)[2,12,18,21-27]

Results of this study showed that HORA was unilateral in the majority of participants, similar to studies in which it was mostly found on one side.[28,18] This study agrees with Rodriguez, who reported HORA to be higher in females.[18]

Several cadaveric studies have demonstrated that HORA originates in the axillary artery, which is situated near the lower border of the teres minor muscle.[18,21,28] We did not discover any aberrant arteries arising from the axillary artery.[18,21] originating from the medial side of the proximal third of the brachial artery, HORA became lateral when it crossed the ulnar artery above the elbow.[22] Rodriguez discovered that HORA has distinct beginnings at several points along the brachial artery.[18,28]

HORA passes anterior to the median nerve as it passes through the arm, crossing it near the antecubital fossa.[22] Patients with neuropathies and radiculopathies should take note of this link between HORA and the median nerve since it has therapeutic implications.[29] The artery was superficial to the brachial artery and the median nerve, but it ran deep to the bicipital aponeurosis at the antecubital fossa. There have been reports of the anomalous artery located anterior to the bicipital aponeurosis.

In this investigation, HORA was located at the antecubital fossa, anterior to the bicipital aponeurosis, superficial to the brachial artery and median nerve.[18,20,30] Consequently, a shallow HORA channel at this site leaves it open to damage during phlebotomy.[30,31]

In rare instances, HORA may anastomose with the median artery at the antecubital fossa, as well as the brachial artery.

Literature around anomalous arteries showed anastomosis between HORA and brachial artery.[20,28,32] However, no such anastomosis was found during our study. In this study, no variations were noted in the median nerve; however, neural variations are reported in many cadaveric studies.[28,33,34]

**Table 1: Prevalence of HORA as documented in earlier research**

| Sort of Specimen | Rate of Occurrence (%) | Positive Finding Cases | Quantity of upper limbs | Study citation |
|---|---|---|---|---|
| **Human Cadavers** | 4.3 | 7 | 150 | Rodriguaz-Baeza et al 1995 |
| **Embryonic Samples** | - | 7 | 10 | Rodriguaz-Baeza et al 1995 |
| **Human Cadavers** | 11 | 11 | 72 | Olive et al 1997 |
| **Embryonic Specimens** | 14 | 21 | 150 | Rodríguaz- Nidenführ et al 2001a |
| **Human Cadavers** | 14 | 53 | 384 | Rodríguaz- Nidenführ et al 2001b |
| **Human Cadavers** | 2.5 | 2 | 80 | Qurratulain et al 2002 |
| **Retrograde radial artery angiography and two-dimensional ultrasonography** | 2 | 28 | 1191 | Yoo et al 2005 |
| **Angiographical analysis** | 8 | 185 | 2211 | Valsechi et al 2006 |
| **Human Cadavers** | 12 | 37 | 304 | Yang et al 2008 |
| **Human Cadavers** | 4 | 2 | 48 | Natis et al 2009 |
| **Human Cadavers** | 8 | 8 | 100 | Nasr et al 2012 |
| **Human Cadavers** | 3 | 3 | 96 | Varekar et al 2013 |

## CLINICAL IMPORTANCE

Anomalous artery in the upper limb is one of the primary causes of unfavorable outcomes post-CABG (coronary artery bypass graft) procedure,7,24,35 & radial forearm flap elevation.36 In addition, dialysis via upper limb arteries is a common practice for patients with chronic renal failure. Adverse cannulation of these arteries can lead to severe consequences like amputation, thrombosis, and gangrene.5

Detailed and precise knowledge of arterial variations is key to effective clinical practice, as this enables clinicians to plan diagnostic and therapeutic interventions. An anomalous artery can be easily missed during angiographic procedures, which can affect the correct diagnosis of the patient.[5,37] Ultrasound screening of arterial variations pre-operatively is a quick and non-invasive method, which can minimize any inaccurate arterial labeling and help plan clinical procedures effectively. A radial artery of high origin's connection to the median nerve makes its existence significant as well. Radiculopathy and neuropathy may be mistakenly identified as nerve compression caused by the radial artery.29 additionally, because the artery traverses the nerve, bleeding from the abnormal artery is a possibility, and nerve treatments may potentially result in arterial injury.

However, its presence could make medical operations like dialysis and cannulation easier.20 A HORA is the most prevalent arterial variation of the upper limb.21 Because of the frequency of these variations, the clinical impact is pretty substantial. Its prevalence can make particular procedures more complex, leading to incorrect diagnoses.31 Many investigations in the literature have revealed information about this aberrant artery, such as the HORA or superficial radial artery.19 The nomenclature used to describe this particular radial artery variant is crucial and will improve clinical outcomes during medical operations. It has been demonstrated in certain investigations that it can be difficult to identify a high-originating radial artery by palpating the distal end of the forearm. Sonography has been suggested in identifying this aberrant radial artery because arterial catheterization is not routinely performed prior to surgical procedures. Many surgeons notice arterial variations during surgery. The literature states that arterial angiography need to be carried out in every situation and anytime the transradial treatment presents challenges with the guidewire or catheter attachment.[24] Furthermore, an abnormally HORA can mislead the surgeons and radiologists during angiography, resulting in misinterpretation of radiology images.[29]

## CONCLUSION

When the current study is compared to the previous research, it can be inferred that the radial artery usually originates from the proximal part of the brachial artery. The radial artery is found to have a typical course running superficially and laterally. No anastomosis has been detected. There were no associated neurovascular anomalies. Thus, the HORA can be used as a risk-free conduit for transradial coronary treatments (angioplasty) and as a graft in coronary artery bypass grafting surgery.

## LIMITATIONS

The study was limited to the faculty of the Medical Education Department.

## SUGGESTIONS / RECOMMENDATIONS

Future studies should measure HORA levels.

## CONFLICT OF INTEREST / DISCLOSURE

There was no conflict of interest among the authors.

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