

Anatomical insight into the variable terminal branching pattern of brachial artery: A narrative review

Quratulain Javaid

Abstract

Blood to the arm is mainly supplied by the brachial artery, which arises at the termination point of the axillary artery at the level of inferior margin of the teres major muscle. The artery ends by dividing into two terminal branches: radial and ulnar. The bifurcation normally takes place at the cubital fossa or around a finger's width below elbow at the level of the neck of the radius bone. For the current narrative review, literature published from 2016 to 2022 was searched on PubMed, Google and Google Scholar databases. Across the globe, variation in terminal branching pattern of the brachial artery was observed. In most cadavers, higher termination was observed in the right upper limb. The variability can have adverse effects on the diagnostic, therapeutic and interventional procedures. As such, awareness of the varying anatomical location of the branches is essential for medical practitioners to avoid procedural errors and misdiagnosis.

Keywords: Anatomical, Variable, Terminal, Branching, Pattern, Brachial artery.

DOI: <https://doi.org/10.47391/JPMA.6563>

Submission completion date: 29-03-2022

Acceptance date: 24-08-2022

Introduction

Blood to the arm is mainly supplied by the brachial artery,¹ which arises at the termination point of the axillary artery at the level of inferior margin of teres major muscle. The brachial artery arises from the third segment of the axillary artery.² The artery terminates by dividing into two terminal branches: radial and ulnar arteries. The bifurcation normally takes place at the cubital fossa or around a finger's width below the elbow at the level of the neck of the radius bone.^{2,3} Brachial artery is in close relation to the median nerve, which, being initially on its lateral side and later crossing it, finally sets it on its medial side.⁴ The brachial artery gives off two terminal branches: medial and lateral. The medial branch crosses over the lateral branch and forms the radial artery, while the lateral branch goes on the medial side to become the ulnar artery.³

Department of Anatomy, Bahria University Health Sciences, Karachi, Pakistan.

Correspondence: Quratulain Javaid. e-mail: docannie2010@gmail.com

ORCID ID. 0000-0002-2858-2896

It is quite common to counter vascular abnormalities in the upper limb.⁵ Tsoucalas et al. documented that prevalence of vascular abnormalities in brachial artery was 20%.⁶ Auwal et al. highlighted the high termination and bifurcation of brachial artery as a common vascular abnormality in many regions of the world.² A recent study in Nepal highlighted various patterns of brachial artery branching. In 5.17% limbs, the terminal branches were at a higher level than normal, 1.72% in the mid-third area of the arm, and 3.45% had in lower one-third region, while in 5.17% area of the arm, the branches were located at a lower position than normal in the region of the shaft of radius.¹ Lalit et al, mentioned variability in 5.35% of the limbs in the form of superficial brachial artery, while in 1.78% of the studied limbs, the brachial artery showed trifurcation into radial, ulnar and common interosseous arteries.⁷ Literature pertaining to brachial vasculature has mentioned the variability to be 13.33% for the termination of brachial artery at tuberosity of radius and 3.33% for the artery having three terminal branches instead of two.⁸ A study showed that 7.14% of limbs had unilateral accessory brachial artery (four on the left side and one on the right side) and 4.29% had bilateral accessory brachial artery.⁹

Kirkov et al. stressed the importance of knowing the anatomical details and the associated variability in terms of brachial artery termination as the vessel is important for procedures ranging from as simple as blood pressure measurement to techniques like flap surgeries and compartment syndrome interventions.¹⁰ Since there are associations that exist between the developmental process of vessels with clinico-anatomical features of the brachial artery, one has to be careful before proceeding to any of the medical interventions involving the brachial artery.¹¹

Developmental anatomy

The variations related to the vessels could be due to the complex embryological developmental process. The brachial artery's origin is linked to the axis artery.¹² The superficial brachial artery is a vital foetal vessel on which morphogenesis of the upper limb vessels is dependent.⁶ During the embryological development, the 7th intersegmental artery gives origin to axis artery. Axial artery and brachial artery arise from the proximal region of the axis artery, while the distal part gives origin to the anterior

interosseous artery and deep palmar arch. Radial artery in the initial phases branches out proximally than the ulnar artery and later establishes its connection with the brachial artery at the level of ulnar artery, and the proximal portion later disappears. In case of high bifurcation, the brachial artery is shorter than normal.¹³ Rohilla et al. documented that embryological errors in the developmental process brings variation in the course of vessels.¹⁴ Sieger et al. documented the role of angioblasts and haemodynamic factors playing an essential role in the variability of the arteries' pattern.¹⁵ Research on embryogenesis explained that bilateral bifurcation of brachial artery could be due to the abnormal path, persistence or obliteration of the primitive vessels.¹⁶

Keeping in view the significance of anatomical knowledge, the current narrative review was planned to determine the anatomical variation in terms of branching pattern of the brachial artery.

Methods, Results and Discussion

For the narrative review, search was conducted on PubMed, Google and Google Scholar databases for studies related to anatomical variability in the terminal branching pattern of brachial artery. The studies included were those published from 2016 to 2022 in the English language and which had detailed methodology and results. Key words used for the search were 'anatomical', 'variable', 'terminal', 'branching', 'pattern', and 'brachial artery'. Research published in any language other than English was excluded. Also, studies with missing or ambiguous methodology and results were excluded.

Of the 30 articles identified, 24(80%) were included.

Diagnostic procedures: The discovery of variability of arteries and their organisation in the body has always been an area of interest for the anatomists.¹⁷ The importance of brachial artery must be known as one should know that while taking blood pressure a varied site of the artery could be a possibility.¹⁸⁻²⁰ The vascular variations of the arm must be understood as the areas are routinely involved in several medical, radiological and surgical procedures.²¹⁻²⁴ Brachial artery is a vital structure in various procedures, like interpretation of angiograms, arteriography, pulse doppler sonography, etc.¹⁸ Similarly, it is a vessel of choice for cardiac ventriculography when femoral artery is inaccessible.²⁵ Inaccurate understanding due to lack of knowledge regarding brachial artery variability can lead to inaccurate reading of angiograms.¹⁶

Therapeutic procedures: Altered anatomical variation pertaining to the division of brachial artery and its termination has high clinical significance.²⁶ Radiologists

and the surgeons must keep in mind the possibility of anatomical variation while doing procedures and interpretation of angiograms.^{27,28} It is also a vessel that can be injured when fistula formation in chronic renal failure patients are planned between cephalic vein and radial artery.²⁵ The variation in terms of bifurcation of brachial artery can create hurdles in procedures like percutaneous brachial catheterisation, repair operations of the brachial region and operations involving arm fractures. The course of the three important nerves -- median, ulnar and radial -- can be severely affected. The hazard of haematoma formation is also one of the clinical considerations.^{16,29} Additionally, the knowledge can prevent any unforeseeable risk like vascular bleeding during the procedures.⁵ The knowledge is also vital for the surgeons who create arterio-venous (AV) fistulas for dialysis patients and to avoid being mistaken for a vein during venipuncture procedure and when drugs are given by intravenous (IV) routes.^{19,30,31} Injection of IV drugs into the ulnar artery in place of vein because of high termination of brachial artery is a hazard and can result into gangrene.^{23,32} Additionally, if such variations are not known, difficulties are faced by the surgeons doing procedures like vascular and flap surgeries.⁸ High bifurcation presents with great issues in interventional radiology.⁶ Also, in the accidental crush injuries involving the elbow joint, brachial artery is a vessel of concern for the orthopaedics.²² Physicians and surgeons planning flap harvesting, arteriography and reconstructive surgeries need to know the variability pattern of brachial artery.³³ There is a dire need for the surgeons and physicians planning for interventions to go for magnetic resonance angiography (MRA) or non-invasive colour doppler scan to rule out any variation of anatomical pattern of brachial artery to avoid any mishap.²⁵ Since there is variability associated with the anatomy of brachial artery, plastic surgeons, physicians and vascular surgeons must be careful to look for variability before they start any procedure.^{30,34} Additionally, in order to prevent iatrogenic injuries in the patients, it is advisable to go for preoperative vessel mapping.^{16,35}

Bifurcation of brachial artery: Around the globe, variance can be observed in terms of terminal branching pattern of brachial artery. Studies have mentioned various regions of the axilla, arm and forearm in connection with their distances from the brachial artery. Some used teres major as a reference point, while others employed coracobrachialis for referencing. A few anatomists have also mentioned distance between terminal bifurcation of brachial artery with respect to humerus and radius.^{2,8,10-12,14,17-32,34,35}

Arm: Different regions of the arm, like proximal, middle,

upper half, have been documented to be the sites of termination of the brachial artery.^{8,14,18,21-24}

Teres major: Some studies have mentioned teres major as a reference point.²⁸ The distances ranging from 2.26cm to 7.5cm below the insertion of teres major have been mentioned to locate the end point of the brachial artery and the start of its division.^{2,12,26}

Coracobrachialis: Some studies have documented Coracobrachialis for referencing. Variable sites ranging from above the muscle, at the level of insertion and also distal to its attachment, have been mentioned as reference points for the termination of the brachial artery.^{10,19,25,31,32}

Humerus: Humerus shaft, intercondylar line and epicondylar region have also been used as points to show

Table: The anatomical variation in the terminal branching pattern of brachial artery.^{3,9-16}

Author	No. of Studied Limbs	No. of Limbs with variation	Age	Gender	Side of the limb with variability	Findings related to termination of brachial artery
Auwal 2017 ² , Nigeria	1	1	Not mentioned	Male	Right	Bifurcation level: 7.5 cm below the lower border of teres major
George 2019 ⁸ , India	60	8	Not mentioned	Not mentioned	Not mentioned	Bifurcation level: 2 cadavers: bifurcation at proximal arm 4 cadavers: bifurcation at radial tuberosity 1 cadaver: bifurcation at mid arm Trifurcation level: Neck of radius (Trifurcation of brachial artery into radial, ulnar and common interosseous artery)
Kirkov 2016 ¹⁰ , Bulgaria	1	1	Not mentioned	Not mentioned	Not mentioned	Bifurcation level: 9.5cm below the axillary region or 20cm above the cubital fossa at the level of coracobrachialis
Sirikonda 2016 ¹¹ , India	80	4	Not mentioned	Not mentioned	Cadaver 1: right Cadaver 2: left Cadaver 3: left Cadaver 4: right	Bifurcation level: Cadaver 1: 2cm below the lower border of teres major Cadaver 2: 2cm below the lower border of teres major Cadaver 3: lower one third of arm over the tendon of biceps brachii Cadaver 4: lower one third of arm above the formation of biceps brachii tendon
Baidya 2018 ¹² , USA	1	1	91	Female	Not mentioned	Bifurcation level: 2.26 cm below the inferior border of teres major
Rohilla 2016 ¹⁴ , India	1	1	Middle aged	Female	Left	Bifurcation level: Brachial termination was observed at the region of middle third of brachium
Rathan 2019 ¹⁷ , UAE	1	1	Not mentioned	Not mentioned	Not mentioned	Bifurcation level: Mid shaft of humerus
Jadhav 2018 ¹⁸ , India	1	1	60	Male	Right	Bifurcation level: Upper one third of the arm
Balasubramanian 2018 ¹⁹ , India	40	1	65	Male	Left	Bifurcation level: 12 cm from the beginning of axillary artery's third part and just above the level of distal attachment of coracobrachialis muscle.
DeOliveira 2018 ²⁰ , Brazil	1	1	Not mentioned	Male	Right	Bifurcation level: Mid region of the shaft of humerus.
Chen 2018 ²² , China	1	1	65	Male	Right	Bifurcation level: One third of the proximal part of brachium.
Saha 2017 ²² , India	1	1	62	Male	Right	Bifurcation level: Upper half of the arm.
Udaiya 2018 ²³ , India	1	1	Around 50	Female	Right	Bifurcation level: Arm.
Mohammadi 2020 ²⁴ , Iran	1	1	Not mentioned	Male	Not mentioned	Brachial artery terminates at the level of midpoint of arm.
Nisa 2021 ²⁵ , India	30	1	Not mentioned	Not mentioned	left	Brachial artery was found to be at the level of insertion of coracobrachialis.
Malhotra 2017 ²⁶ , India	1	1	72	Male	Right	Bifurcation level: The brachial artery terminated 3 cm below the lower border of teres major muscle
Soog 2018 ²⁷ , Iran	1	1	35	Male	Left	Bifurcation level: Middle third of the proximal arm.
Ojha 2019 ²⁸ , India	80	2	Not mentioned	Male and female	Right	Bifurcation level: Cadaver 1 and 2: lower border of teres major
Sucharita 2022 ²⁹ , India	40	1	Not mentioned	Not mentioned	Right	Terminal division at the level of 6 cm above the line joining the two epicondyles of humerus bone.
Jayasree 2017 ³⁰ , India	50	4	Not mentioned	Not mentioned	Bilateral in both the cadavers	Bifurcation level: Mid region of arm near the distal attachment of coracobrachialis.
Al Talawah 2017 ³¹ , KSA	1	1	Not mentioned	Male	Right	Bifurcation level: 10cm proximal to the intercondylar line.
Abeywardhana 2019 ³² , Sri Lanka	54	3	Not mentioned	Not mentioned	Left Left	Bifurcation level: Cadaver 1: Axilla (bifurcation) Cadaver 2: Mid humerus (bifurcation) Triifurcation level: Cadaver 3: Neck of radius
Kaur 2017 ³⁴ , India	40	4	Not mentioned	Not mentioned	Cadaver 1: left Cadaver 2: left Cadaver 3: left Cadaver 4: right	Bifurcation level: Cadaver 1: 8 cm above the elbow joint Cadaver 2: 20 cm above the elbow joint Cadaver 3: 7 cm above the elbow joint Cadaver 4: 7.5 cm above the elbow joint
Phalgunan 2018 ³⁵ , India	60	3	Not mentioned	Cadaver 1: male Cadaver 2: male Cadaver 3: male	Cadaver 1: left Cadaver 2: left Cadaver 3: right	Bifurcation level: Cadaver 1: 13 cm above the elbow joint Cadaver 2: 7.5 cm above the elbow joint Cadaver 3: 13.5 cm above the elbow joint

UAE: United Arab Emirates; KSA: Kingdom of Saudi Arabia

the termination of the brachial artery.^{17,20,29,31,32}

Region proximal to elbow joint: Region from the brachial artery ending point to the elbow joint has been mentioned ranging from 7cm to 20cm.^{34,35}

Trifurcation of brachial artery: The brachial artery in majority of the cadaveric limbs has been observed to have bifurcation at the level of its termination. A few of the limbs have demonstrated the presence of three vessels at the point where the vessel terminates.^{8,32}

Gender and the side of the limb as determinant factors: In most studies, male cadavers were observed to have variability, while some of the studies showed anatomical variance in female cadavers. Likewise, preponderance of right-sided terminal branching pattern of the brachial artery was noticed, while some studies documented left-sided changes in the pattern, and only 2(7.4%) studies showed anatomical changes bilaterally (Table).

Recommendations

Radiologists, vascular surgeons, orthopaedics and cardiologists should be updated about the possible variances as it can affect diagnostics and therapeutic procedures. Additionally, the medical curriculum should focus on the addition of the topic of variance in anatomy, medicine, surgery and radiology books so that the newcomers should recognise the existence of variable arterial pattern pertaining to the brachial artery. Keeping in mind the clinical significance of the anatomical position of the brachial artery and its possible variations, the knowledge should be taught to the students of anatomy and medicine.

Conclusion

Variations in the terminal branching pattern of the brachial artery have been reported from across the globe. In most cadavers, higher termination was observed in the right upper limb. The variability can have adverse effects on the diagnostic, therapeutic and interventional procedures. As such, awareness of the varying anatomical location of the branches should be ensured among medical practitioners to avoid procedural errors and misdiagnosis.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

References

- Khatun S, Shah DK. Higher Termination of Brachial Artery in Cadavers in the Department of Anatomy of a Medical College: A Descriptive Cross-sectional Study. *JNMA J Nepal Med Assoc* 2021;59:763-6. doi: 10.31729/jnma.6483.
- Auwal AM, Zagga AD, Asala SA. Unilateral high bifurcation of brachial artery: a case report. *Anat j Afr* 2017;6:916-8.
- Bagal G, Takale S. A Cadaveric Study on Division of Brachial Artery with Its Embryological Basis and Clinical Significance. *J Med Sci Clin Res* 2015;3:8708-12. Doi: 10.18535/jmscr/v3i12.41.
- Sthapak E, Pasricha N, Bhatnagar R. Relation of median nerve with brachial artery: a cadaveric study. *J Anat Science* 2019;27:10-4.
- Baisakh P, Mohanty BB, Panda SK, Chinnara PK. High Division and Variation in Branching Pattern of Brachial Artery with Superficial Course of Radial Artery: A Case Report. *Int J Pharm. Sci Rev Res* 2015;32:43-4.
- Tsoucalas G, Eleftheriou A, Panagouli E. High Bifurcation of the Brachial Artery: An Embryological Overview. *Cureus* 2020;12:e7097. doi: 10.7759/cureus.7097.
- Lalit M, Piplani S. A cadaveric study of brachial artery and its variations with its ontogenic basis: An Anatomical Perspective. *Int J Anat Res* 2021;9:7844-50. DOI: 10.16965/ijar.2020.233.
- George JR, Francis J, Samuel JE, Francis T. Morphology And Variations Of Brachialartery In Cadavers. *Int J Anat Res* 2019;7:6680-4. DOI: 10.16965/ijar.2019.202.
- Chakravarthi KK, Ks S, Venumadhav N, Sharma A, Kumar N. Anatomical variations of brachial artery - its morphology, embryogenesis and clinical implications. *J Clin Diagn Res* 2014;8:AC17-20. doi: 10.7860/JCDR/2014/10418.5308.
- Kirkov V, Iliev A, Hinova-Palova D. Variations In Branching Pattern Of The Brachial Artery. *Praemedicus* 2016;33:41-4.
- Sirikonda P, Nalluri HB. An Anatomical Insight Into High Division Of Brachial Artery: A Study In 40 Cadavers. *Int J Anat Res* 2016;4:1864-8. DOI: 10.16965/ijar.2015.353.
- Baidya R, Kumar S. Termination of the brachial artery in the arm-a case report. *IJBAMR*. 2018;7:287-90.
- Satyanarayana N, Sunitha P, Shaik MM, Devi PSV. Brachial artery with high up division with its embryological basis and clinical significance development. *Int J Anat Var* 2010;3:56-8.
- Rohilla A, Parmar P, Singh K, Rohilla J. Unilateral high division of brachial artery and its clinical significance. *Int J Res Med Sci* 2016;4:5513-5. DOI: 10.18203/2320-6012.ijrms20164244.
- Sieger J, Patel L, Sheikh K, Parker E, Sheng M, Sakthi-Velavan S. Superficial brachioulnar artery and its clinical significance. *Anat Cell Biol* 2019;52:333-6. doi: 10.5115/acb.19.008.
- Gupta R, Pham L, Hsia C, Daboul R, Galen B, Gemechu J. Anatomical Variation of High Bilateral Brachial Artery Bifurcation: A Case Report. *Faseb J* 2020;34:s1. Doi: 10.1096/fasebj.2020.34.s1.0481.
- Rathan R, Salama MNF. Termination of the Brachial Artery in the Arm and Its Clinical Significance. *Int J Med Health Sci* 2019;13:65-8.
- Jadhav SD, Pawar SE. High Division of Brachial Artery and Its Clinical Insight: A Case Report. *Int J Curr Med Appl Sci* 2018;19:27-9.
- Balasubramanian R, Subramaniam C, Virupaxi RD, Yadav SK. Unilateral higher division of brachial artery. *J Sci Soc* 2018;45:43-6.
- De Oliveira JG, Ferreira MD, De Souza Cunha MG. Arterial Variation: Higher Bifurcation of the Brachial Artery into Radial and Ulnar Arteries in the Arm of a Male Corpse. *J Morphol Sci* 2018;35:212-5. DOI: 10.1055/s-0038-1675363.
- Chen X, Fu C, Guo C, Wang J, Jiang Z, Leng L, et al. Variations of Musculocutaneous Nerve Combined with High Bifurcation of the Brachial Artery. *Open Access Library Journal* 2018;5:1-5. DOI: 10.4236/oalib.1104791.
- Saha J, Saha D, Mazumdar S. Case Report Unilateral high-up division of Brachial artery in the arm-A case report. *Indian Journal of Basic and Applied Medical Research* 2017;6:148-51.
- Udaiyani N, Sagwan N, Herswani I, Bhatnagar V, Lahange SM. Variant Branching Pattern Of Brachial Artery In Context To Its Higher Bifurcation: A Case Report. *Int J Anat Res* 2018;6:5926-8. DOI: 10.16965/ijar.2018.377.

24. Mohammadi A, Alizadeh R, Rajai M, Ebrahimi S, Gholamnejad F, Moradi F. The Unilateral High Bifurcation of the Brachial Artery. *Anat Sci J* 2020;17:43-6.
 25. Nisa G, Itoo MS, Nazir M. Variations in Branching Pattern of Brachial Artery in Upper Limb-A Cadaveric Study and Medical Emergency. *IOSR J Dent Med Sci* 2021;20:1-6. DOI: 10.9790/0853-2004110106.
 26. Malhotra R, Singh R, Wadhawan M, Malhotra M. High termination of brachial artery with tortuous superficial radial and ulnar arteries: Anatomical perspectives and clinical implications. *Indian J Clin Anat Physiol* 2017;4:284-7. Doi: 10.18231/2394-2126.2017.0072.
 27. Soog AJ, Kharazinejad E, Absalan F. Variation in Bifurcation Pattern of Brachial Artery. *Anat Sci J* 2018;15:69-72.
 28. Ojha P, Prakash S. Variations In Branching Pattern Of Brachial Artery– A Study In Cadavers. *Int J Sci Res* 2019;8:33-6.
 29. Sucharitha TM, Hema L, Phanindra SV. Unilateral high division of brachial artery. *Natl J Clin Anat* 2016;5:110-3.
 30. Jayasree C, Reddy CK. A Cadaveric study on variations in brachial artery–An Anatomical perspective. *Perspectives in Medical Research* 2017;5:29-32.
 31. Al Talalwah W. A case report of a high brachial artery bifurcation in relation to clinical significance of artificial arteriovenous fistula. *Acta Med Int* 2017;4:22-4. DOI: 10.5530/ami.2017.4.5.
 32. Abeywardhana UN, Wahalawatte YR, Dissanayake JK, Amaratunga HA. Anatomical variations of the terminal branching of the brachial artery. *Sri Lanka Anatomy Journal (SLAJ)* 2019;3:12–5. DOI: 10.4038/slaj.v3i2.104.
 33. Hansdak R, Arora J, Sharma M, Mehta V, Suri RK, Das S. Unusual branching pattern of brachial artery - Embryological basis and clinicoanatomical insight. *Clin Ter* 2015;166:65-7. doi: 10.7417/CT.2015.1817.
 34. Kaur A, Sharma A, Sharma M. Variation in Branching Pattern of Brachial Artery. *Int J Sci Stud* 2017;5:213-7. Doi: 10.17354/ijss/2017/192.
 35. Phalgunan V, Nallathambi A. A Study on Bifurcation of Brachial Artery in South Indian Population (Tamil Nadu and Puducherry). *Indian J Anat* 2018;7:74-7. DOI: 10.21088/ija.2320.0022.7118.14.
-