Print ISSN: 2321-6379
Online ISSN: 2321-595X
DOI: 10.17354/ijss/2017/192

Original Article

Variation in Branching Pattern of Brachial Artery

Amandeep Kaur[1], Anshu Sharma[2], Mahesh Sharma[3]

[1]Demonstrator, Department of Anatomy, Government Medical College, Sector 32, Chandigarh, Punjab, India, [2]Associate Professor, Department of Anatomy, Government Medical College, Sector 32, Chandigarh, Punjab, India, [3]Head, Department of Anatomy, Government Medical College, Sector 32, Chandigarh, Punjab, India

Abstract

Introduction: The brachial artery (BA) provides main arterial supply to the arm. It begins as the continuation of 3rd part of the axillary artery, at the level of inferior border of teres major muscle. It ends at the level of the neck of radius by dividing into radial arteries (RAs) and ulnar arteries (UAs). We tried to find variation in the branching pattern of BA of the artery.

Aim: The aim of this study is to discuss variations in branching pattern of BA and also their embryological and clinical significances.

Methods: This study was conducted on 40 upper limbs from the Department of Anatomy, Government Medical College and Hospital, Chandigarh.

Results: In this study, we observed higher division of BA into RA and UA above the elbow joint in 4 cases. UA was seen trifurcated at the lower border of pronator teres in cubital fossa in 3 cases. Superior ulnar collateral artery arose from UA in 2 cases, and inferior ulnar collateral artery was absent in 4 cases.

Conclusions: The knowledge of variation in origin and course of BA is useful for orthopedicians, physicians, radiologist, vascular, and plastic surgeons. Variation in branching pattern of arteries of the upper limb has diagnostic and interventional significance.

Key words: Brachial artery, Higher division, Median nerve, Radial artery, Ulnar artery

INTRODUCTION

Brachial artery (BA) is the main artery of the arm. It begins at the lower border of teres; major muscle as a continuation of the axillary artery and terminates by dividing into radial artery (RA) and ulnar artery (UA) at the level of the neck of radius in cubital fossa (CF). The BA is wholly superficial, covered anteriorly only by skin, and superficial and deep fasciae. The bicipital aponeurosis crosses it anteriorly at the elbow, separating it from the median cubital vein at its lower part. The median nerve (MN) crosses it from lateral to medial side near the distal attachment of coracobrachialis. BA is posteriorly related to the long head of triceps, separated by the radial nerve and profunda BA (PBA), and then successively by the medial head of triceps, the attachment of coracobrachialis and brachialis. Proximally, the MN and coracobrachialis lie laterally while distally the biceps and muscles overlap the artery. Proximally, the medial cutaneous nerve of the forearm and ulnar nerve lie medially, while distally the MN and basilic vein lie medially. Two venae comitantes running with the BA, connected by transverse and oblique branches. Branches of BA are PBA, superior ulnar collateral artery (SUCA), middle and inferior ulnar collateral artery, muscular branches, nutrient branch, and two terminal branches are RA and UA.[1] Variations in the pattern of upper limb arteries have been reported since the 17th century.[2] Quain's in 1844 published the first systematic description and classification of these variations on the basis of cadaver dissection and angiographic studies.[3] Variations in upper limb arteries are fairly common. The most commonly reported variation in the higher division (HD) of BA into RA and UA above the CF. According to the compendium of human anatomic variation, major variations are present in about 25% of the subjects studied for the BA. The variations in the form of high proximal division into terminal branches occur in the RA (15%), UA (2%), and common interosseous artery.[2]

Various authors have mentioned about the incidence of high origin of RA. This HD may occur at any point in the

Access this article online

www.ijss-sn.com

Month of Submission : 02-2017
Month of Peer Review : 03-2017
Month of Acceptance : 03-2017
Month of Publishing : 04-2017

Corresponding Author: Amandeep Kaur, Department of Anatomy, Block E, Government Medical College, Sector 32, Chandigarh, Punjab, India. Phone: +91-8528726226. E-mail: aman.pgimer@gmail.com

normal course of the vessel but it is more common in the middle third. The two vessels run parallel to each other to the bend of the elbow, in the usual position of the BA. From this point, one branch follows the normal course of the RA through the forearm, and the other one takes the normal course of the UA. This arrangement is considered a simple HD of the BA.[2] In this study, we focused on the anatomical topography of the BA branching pattern variation and discussed its morphological and clinical significance.

MATERIALS AND METHODS

This study was conducted on 40 upper limbs (17 left and 23 right) in Government Medical College and Hospital, Chandigarh. Dissection was done as per the guidelines. Structures were identified, cleaned, and photographed. After dissection of BAs, following observations are noted:

1. Length of BA.
2. Branches of BA. Site of origin of all branches was noted and the distance between proximal point of main trunk and origin of branch was measured.
3. Relations of BA with MN in arm.
4. Relations of BA with neighboring structures in CF we studied.

Aim

The aim of the present study is to discuss variations in branching pattern of BA and also their embryological and clinical significances. These variations were compared cases in available literature of such variations.

RESULTS

In this study, we found higher bifurcation of BA in 4 cases (3 left and 1 right upper limbs; 10%), out of 40 upper limbs. In case 1 (left upper limb), we detected that BA divided into UA and RA about 8 cm above the elbow joint (Figure 1a). Total length of BA was 3 cm. The MN was lying medial to the BA in the upper part of arm. At the level of bifurcation of BA, MN crossed artery anteriorly from medial to lateral side of artery. After the division of the artery, the nerve was present first behind the RA and then between the RA and UA. Later in the lower part of arm, it remained on medial side of RA (Figure 1c). In lower part of arm, UA was medial to the MN. In the CF, contents are MN, biceps brachii (BB) tendon, RA, and radial nerve from medial to lateral side. PBA originated from BA about 2 cm above the bifurcation of the BA. It originated in the form of two small branches and then coursed through the spiral groove in posterior compartment of arm. SUCA arose from UA about 6.5 cm above the elbow joint (Figure 1b). Inferior ulnar collateral artery was absent. In the lower part of arm,

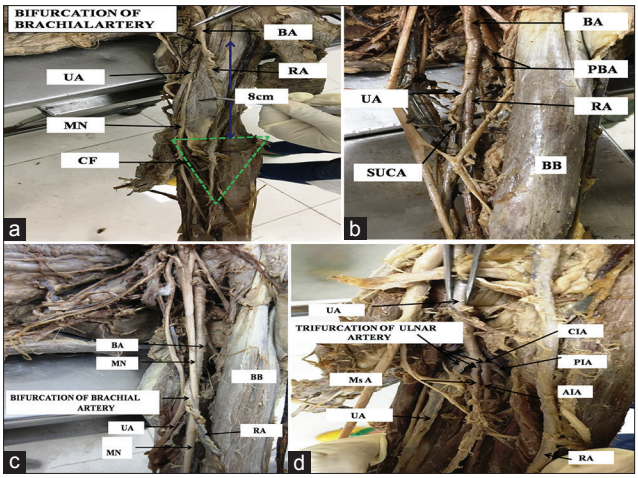

Figure 1: (a) Bifurcation of brachial artery and also showing median nerve lying between ulnar and radial artery in the lower part of arm (left arm). (b) Branches of BA and also showing superior ulnar collateral artery arising from the ulnar artery. Profunda BA arising from BA in the form of two small branches. (c) Relations of MN with BA, RA, and UA. In upper part of arm, MN lying medial to BA then cross it anteriorly. MN lying between UA and RA in lower part of arm. (d) Trifurcation of ulnar artery. BA: Brachial artery, UA: Ulnar artery, RA: Radial artery, MN: Median nerve, CF: Cubital fossa, SUCA: Superior ulnar collateral artery, BB: Biceps Brachii, MA: Muscular artery, CIA: Common interosseous artery, AIA: Anterior interosseous artery, PIA: Posterior interosseous artery

muscular branches also originated from UA. RA traveled on lateral side and was running on anterior surface of BB muscle in lower part of arm. RA entered into forearm by passing medial to the brachioradialis. In the forearm, the RA ran superficially as written in standard textbooks of anatomy. The UA passed deep-to-deep head of pronator teres in forearm. In CF, UA trifurcated at the lower border of pronator teres. The two branches were muscular and common interosseous artery. The third branch was the continuation of UA itself. Common interosseous artery divided into anterior and posterior interosseous artery (Figure 1d).

In case 2 (left upper limb), we observed that BA terminated into RA and UA in the left upper limb about 20 cm above the elbow joint. Total length of BA was 4 cm. In the upper part of arm, the MN was lying lateral to the BA. After the division of the artery, the nerve was present first behind the RA and then between the RA (laterally) and UA (medially). Here, relations of MN with UA and RA are same as in case 1. Later in the lower part of arm, it remained on medial side of RA. In lower part of arm, UA was medial to the MN (Figure 2a). In the CF, contents are UA, MN, BB tendon, RA, and radial nerve from medial to lateral side. PBA originated from BA about 2 cm above the bifurcation of the BA (Figure 2a). It originated in the form of two small branches and then coursed through the spiral groove in posterior compartment of arm same as

in case 1. SUCA arose from UA about 18 cm above the elbow joint. Inferior ulnar collateral artery was absent as in case 1. Muscular branches in the lower part of arm also originated from UA. In lower part of arm, RA traveled on lateral side and was running on anterior surface of BB muscle. In the forearm, the course of RA was normal. The UA passed deep-to-deep head of pronator teres in forearm. In CF, UA divided into three branches at the lower border of pronator teres. The two branches were median and common interosseous artery. The third branch was the continuation of UA itself. Common interosseous artery divided into anterior interosseous and posterior interosseous artery (Figure 2b).

In case 3 (right upper limb) and 4 (left upper limb), we found bifurcation of BA into RAs and UAs about 7.5 cm (case 3) and 7 cm (case 4), respectively, above the elbow joint. Both the arteries had superficial course in the arm along the medial aspect of BB. PBA originated as a single branch about 3 cm above the bifurcation of BA in both cases. SUCA (8.5 cm in case 3 and 8 cm in case 4, above elbow joint) and muscular branches arose from BA in both cases. In the lower part of arm, RA was seen crossing the MN anteriorly from medial to the lateral side. After this, MN lying between RA and UA. In the CF, UA seen deep to the pronator teres separating it from MN. Further course of RA and UA was normal. The contents of CF from medial to lateral side were UA, MN, RA, and radial nerve in both cases.

DISCUSSION

Developmental Basis of Variation

The axis artery of the upper limb is derived from the seventh cervical intersegmental or subclavian artery. This artery grows distally along the ventral axial line and terminates in a palmar capillary plexus in the hand. Axillary artery, BA, anterior interosseous artery, and deep palmar arch develop from the main trunk of axis artery. RAs and UAs develop later as sprouts of the axis artery close to bend of the elbow. Initially, the RA arises more proximally than the UA. Later, it establishes a new connection with the main trunk at or near the level of origin of the UA. Usually, the upper portion of the original stem disappears so that the RAs and UAs arise at the same level.[4] In this study, both the RAs and UAs originated more proximally from the BA leading to its termination into RAs and UAs in the middle of the arm. Persistence of the upper portion of RA arising from BA proximal to origin of UA and the failure of establishing the new connection of RA with BA at the level of origin of UA result in this type of variation. Various vascular variations of upper limb results from the persistence or elimination of parts of these arteries.

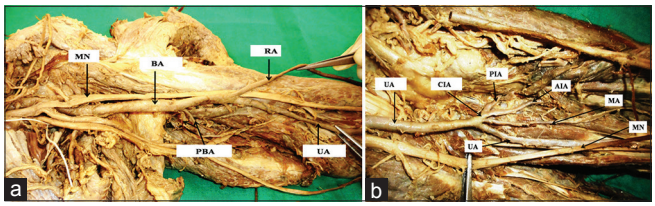

Figure 2: (a) Bifurcation and branches of BA and also showing relations of median nerve with BA, radial, and ulnar artery (left side). (b) Trifurcation of ulnar artery. BA: Brachial artery, RA: Radial artery, MN: Median nerve, BB: Biceps Brachii, PBA: Profunda brachii artery, UA: Ulnar artery, MA: Median artery, CIA: Common interosseous artery, AIA: Anterior interosseous artery, PIA: Posterior interosseous artery

According to Arey, the anomalous blood vessels may be due to (i) the choice of unusual paths in the primitive vascular plexuses, (ii) the persistence of vessels normally obliterated, (iii) the disappearance of vessels normally retained, (iv) incomplete development, and (v) fusions and absorption of the parts usually distinct.[5] Anomalies of the forelimb arterial tree are fairly common, probably because they have multiple and plexiform sources, display a temporal succession of emergence of principles arteries, anastomoses and periarticular networks, and some path that is initially functionally dominant subsequently regress. In general, anomalous pattern may present as differences in the mode and proximodistal level of branching; the presence of unusual compound of arterial segments; aberrant vessels that connect with other principal vessels, arcade, or plexuses; vessels that occupy exceptional tissue planes (e.g., superficial fascia instead of the usual subfacial route) or which have unexpected neural, mycological, or osteon ligamentous relationships.[6] Early limb bud receives blood through intersegmental arteries, which contribute to a primitive capillary plexus. At the tip of the limb bud, there is a terminal plexus that is constantly renewed in a distal direction as the limb grows. Later, one main vessel supplies the limb and the terminal plexus; it is termed the axis artery. The aforesaid terminal plexus at the tip of the limb bud is separated from the outer ectodermal sleeve of the limb by an avascular zone of mesenchyme. This avascular region contains an extracellular matrix consisting largely of hyaluronic acid. Removal of this hyaluronic acid by hyaluronidase results in vascularization of the tissue since partial degradation products of hyaluronic acid are angiogenic. Thus, ectodermal-mesenchymal interactions and extracellular matrix components are controlling the initial patterning of blood vessels within the limb.[7]

It is not uncommon to find variations in the branching pattern of arteries of the upper limb. Although the first reported arterial variation in the upper limb was by Von Haller in 1813,[3,8] incidence of HD of BA is 25% in various populations of the world.[3] The highest percentage of variations of BA is mainly form by high origin of RA and

UA. High origin of RA occurrence is 3-15%, as reported by different authors.[9-12]

Satyanarayana *et al.* also described a case of early division of BA in middle of the right arm into RA and UA.[13] A case of higher bifurcation of the BA (right side = 20 cm and left side = 21.5 cm) above the CF was described by Rossi *et al.*[14] Singh *et al.* also observed that BA divided into RA and UA about (right side = 7.5 cm and left side = 10.5 cm) above the line joining humeral epicondyles.[15] Similar findings were noted by Puspalatha[16] and NM. Suresh *et al.*[17] On the other hand, Gupta *et al.* reported about an unusually short segment BA with bifurcation proximal at the level of insertion of coracobrachialis in 2 out of 20 cadavers.[18] Varlekar *et al.* also described HD of BA in 3 cases out of 48 cadavers.[19] In this study, we also found HD of BA in 4 cases (1 right and 3 left upper limbs). In all 4 cases, we observed that BAs terminated (in case 1 = 8 cm, case 2 = 20 cm, case 3 = 7.5 cm, and case 4 = 7 cm) above the elbow joint (Figures 1a, 2a, 3, and 4).

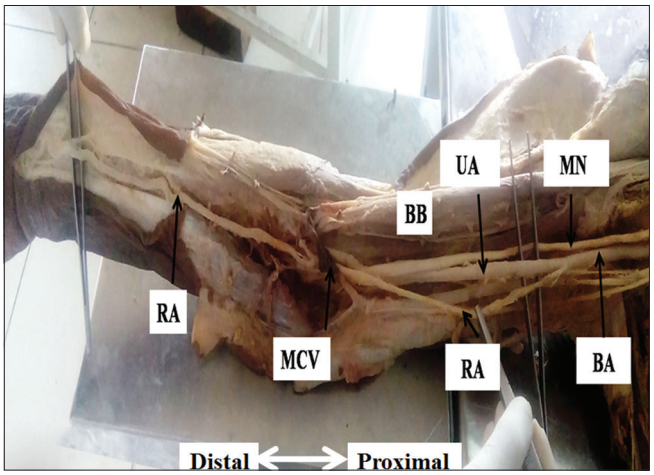

Figure 3: Higher bifurcation of BA and relations of the median nerve with BA, radial, and ulnar artery in arm on the right side. BA: Brachial artery, RA: Radial artery, UA: Ulnar artery, MN: Median nerve, MCV: Median cubital vein, BB: Biceps Brachii

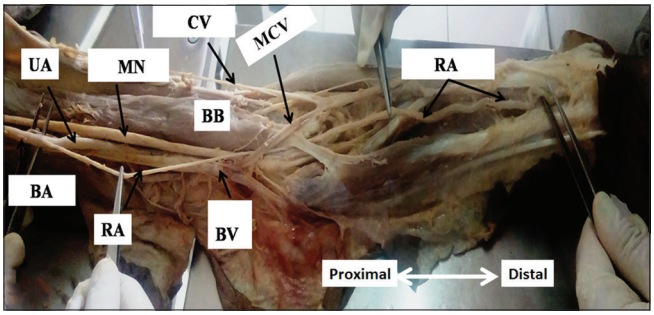

Figure 4: Bifurcation of brachial artery and also showing median nerve crossing ulnar artery anteriorly in lower part of arm (left arm) and then median nerve lying between ulnar and radial artery in cubital fossa. BA: Brachial artery, UA: Ulnar artery, RA: Radial artery, MN: Median nerve, CV: Cephalic vein, MCV: Median cubital vein, BV: Basilic vein, BB: Biceps Brachii

Icten *et al.* reported about a case in which RA arising from the axillary artery bilaterally in a cadaver.[20] Similar findings were observed by Okaro and Jiburum.[4] On the other side, a case of high origin of RA from 3rd part of axillary artery proximal to the two roots of the MN was noticed by Balchandra *et al.*[19] In this study, we observed that RA and UA had high origin from BA in 4 cases (1 right and 3 left upper limbs). Teli *et al.* reported a case of HD of BA. In this case, BA before its termination gave out the posterior circumflex artery, PBA, and SUCA. The MN crossed RA from lateral to medial side as it traveled to CF.[21] In this study, PBA originated in the form of two small branches (case 1 [Figure 1b], and case 2 [Figure 2a], left upper limbs) and as single branch (case 3, right side, and 4, left side) from BA before its termination, whereas SUCA arose from UA (case 1=6.5 cm [Figure 1b] and case 2= 18 cm,) and BA (case 3= 8.5 cm and case 4= 8 cm) above the elbow joint. The inferior ulnar collateral artery was absent in these 4 cases. We also noted that RA was seen crossing the MN anteriorly from medial to lateral side, in lower part of arm (Figures 3 and 4), and the rest of the course was same in the forearm (case 3 and 4).The RAs and UAs descended parallel to each other in the arm, over the BB muscle. On the other hand, MN lying medial to the BA in the upper part of arm and crossed artery anteriorly from medial to lateral side in case 1 (left upper limb (Figure 1c). After the termination of the artery, the nerve was present first behind the RA and then between the RA and UA (case 1 [Figure 1b] and case 2 [Figure 2a]).

Gujar *et al.* studied 30 cadavers. In one case, the BA was divided into middle third of arm into RAs and UAs. The PBA arose from BA but the superior and inferior ulnar collateral branches arose from the UA. In other case, the RA arose from 3rd part of the axillary artery from ventral side in the axilla. The RA passed downward and cross MN from medial to lateral side and then pass along medial side of the BB muscle.[22] Similar findings were noted in this study, but inferior ulnar collateral artery was absent in these cases. Relations of RA and MN was found same in cases 3 and 4 (Figure 3) as previously mentioned by Gujar.[22]

Vishal and Pretty reported about a case in which BA bifurcated into a radial and ulnar branch 9.5 cm distal to the lower border of teres major muscle. The ulnar branch trifurcated at the proximal border of pronator teres muscle. One branch continued as similar course as that of UA forming the superficial palmer arch. The other two branches were muscular and common interosseous artery.[13] In this study, we found similar branching pattern of UA in case 1 (Figure 1d) and (Figure 2b), but in case 2 muscular branch was replaced by median artery but the difference is in relation of the vessel and MN (Figures 1c

and 2a). In case 1, the MN was lying medial to the BA in the upper part of arm. At the level of bifurcation of BA, MN crossed artery anteriorly from medial to lateral side of artery. After the division of the artery, the nerve was present first behind the RA and then between the RA and UA (Figure 1c). In case 2, MN lying lateral to BA. After the division of the artery, the nerve was present first behind the RA and then between the RA (laterally) and UA (medially) (Figure 2a).

The unusual division of BA can be explained on the basis of embryological development of vessels of upper limb mentioned above.

Clinical Importance

Knowledge of possible variations in the branching pattern of various arteries is important during vascular and reconstructive surgery. These variations are of great importance in cardiac catheterization for angioplasty and arterial grafting also. These variations of the BA may cause difficulties while measuring the blood pressure. Being superficial, the RA may be mistaken as a vein and the accidental injection of some drugs may cause reflex vascular occlusion, resulting in disastrous gangrene of hand.[15] The superficial course of RA can easily be injured by trauma. Arterial thrombosis, producing ischemia after radial cannulation, may be related to high risk of tissue gangrene or amputation. Angiographic images and Doppler ultrasound imaging are of considerable importance during invasive and non-invasive investigative procedures due to this kind of variations.[4] The surgeons should be aware of arterial variations in the region before embarking on the procedure.

CONCLUSION

The reported cases of variations revealed higher termination and bifurcation of BA more on the left side (3 cases) of cadavers. In this study, we observed that SUCA arose from UA in 2 cases and inferior ulnar collateral was absent in all 4 cases. This study must be quite interesting for the clinicians to be aware of the possible variations in the branching pattern of the arteries to avoid complications in surgical and diagnostic procedures.

REFERENCES

1. Standring S, Borley NR, Collins P, Crossman AR, Gatzoulis MA, Healy JC, *et al*. Gray's Anatomy. The Anatomical Basis of Clinical Practice. 40th ed. New York: Churchill Livingstone; 2008. p. 981.
2. Bergman RA, Thompson SA, Afifi AK, Saadeh FA. Compendium of Human Anatomic Variation. Baltimore: Urban and Schwarzenberg; 1988.
3. Bidarkotimath S, Avadhani R, Kumar A. Primary pattern of arteries of upper limb with relevance to their variations. Int J Morphol 2011;29:1422-8.
4. Okoro IO, Jiburum BC. Rare high origin of the radial artery: A bilateral, symmetrical case. Niger J Surg Res 2003;5:70-2.
5. Arey LB. Developmental anatomy. In: Development of the Arteries. 6th ed. Philadelphia: W.B. Saunders' Co.; 1957. p. 375-7.
6. Williams PL, Bannister LH, Berry MM, Collins P, Dyson M, Dussek JE, Ferguson MW, editors. Gray's Anatomy. 38th ed. London: Churchill Livingstone; 1999. p. 319, 1539.
7. Rodriguez-Baeza A, Nebot J, Ferreira B, Reina F, Perez J, Sanudo JR, *et al*. An anatomical study and ontogenetic explanation of 23 cases with variations in the main pattern of the human brachio-antebrachial arteries. J Anat 1995;187:473-9.
8. Bidarkotimath S, Avadhani R, Kumar A. An anatomical study of primary pattern of arteries of upper limb with relevance to their variations. NUJHS 2012;2:8-14.
9. Anson BJ. In: Thomas M, editor. Morris. Human Anatomy in the Cardiovascular System-Arteries and Veins. New York: McGraw-Hill Book; 1966. p. 708-24.
10. De Garis CF, Swartley WB. The axillary artery in white and Negro stocks. Am J Anat 1928;41:353-97.
11. Muller E. Contributions to the Morphology of the Vessel System. The Human armaments. Anatomical notebooks 1903;22:377-575.
12. Karlsson S, Niechajev IA. Arterial anatomy of the upper extremity. Acta Radiol 1982;23:115-21.
13. Satyanarayana N, Sunitha P, Shaik MM, Devi PS. Brachial artery with high up division with its embryological basis and clinical significance. Int J Anat Var 2010;3:58.
14. Rossi WC Jr, Esteves A, Simões JS, Fernandes GJ. Bilateral high division of the brachial artery in one human male cadaver: Case report. J Morphol Sci 2011;28:204-7.
15. Singh H, Gupta N, Bargotra RN, Singh NP. Higher bifurcation of brachial artery with superficial course of radial artery in forearm: Case report. JK Sci 2010;12:39-40.
16. Puspalatha M, Haq I. Bilateral high divisions of the brachial artery - A case report. Anat Karnataka 2010;4:59-61.
17. Gupta J, Jain R, Patil M. A study of brachial artery with high up division and its clinical significance. Int J Bioassays 2012;1:116-8.
18. Icten N, Sullu Y, Tuncer I. Variant high-origin radial artery: A bilateral case. Surg Radiol Anat 1996;18:63-6.
19. Varlekar P, Chavda H, Kubavat D, Nagar S, Saiyad SS, Lakhani C. Higher bifurcation of brachial artery with superficial course of radial artery in forearm: A study report. Int J Med Sci Public Health 2013;2:703-6.
20. Baeza AR, Nebot J, Ferreira B, Reina F, Perez J, Sanudo JR, *et al*. An anatomical study and ontogenetic explanation of 23 cases with variations in the main pattern of the human brachio-antebrachial arteries. J Anat 1995;187:473-9.
21. Teli C, Kate NN, Paarthiban N. High division and variation in brachial artery branching pattern. J Dent Med Sci 2013;3:68-70.
22. Gujar SM, Oza SG, Shekhawa JP, Vikani SK, Prajapati SB. A study on division of brachial artery and its clinical correlations. Int J Anat Res 2014;2:208-12.

How to cite this article: Kaur A, Sharma A, Sharma M. Variation in Branching Pattern of Brachial Artery. Int J Sci Stud 2017;5(1):213-217.

Source of Support: Nil, **Conflict of Interest:** None declared.