

Anatomical variation of brachial artery bifurcation

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ABSTRACT

الأهداف: رصد وملاحظة التفرع الثنائي النهائي للشريان العضدي

الطريقة: أجريت دراسة في قسم التشريح، كلية الطب، جامعة الملك عبد العزيز، جدة، المملكة العربية السعودية خلال الفترة من ديسمبر 2011م حتى فبراير 2013م. تم فحص و تشريح 60 جثة بالغة. تم تحديد مستوى التفرع الثنائي النهائي للشريان العضدي بالنسبة لعنق عظمة الكعبرة ومن ثم تصوير كل من التفرع الطبيعي وغير الطبيعي.

النتائج: وجدنا تفرع في المكان الطبيعي في 13 حالة (21.7%) فيما لوحظ تغير بسيط في حوالي 33 حالة (55%) حيث كان التفرع منخفض عن عنق عظمة الكعبرة باستيمترات قليلة. إضافة إلى وجود 7 حالات (11.7%) ينتهي عندها الشريان العضدي في مستوى أعلى من عنق عظمة الكعبرة باستيمترات قليلة في محيط الحفرة المرفقية. كما رصد في 6 حالات (10%) وجود التفرع الثنائي النهائي للشريان العضدي في مستوى أعلى من منتصف العضد وفي إحدى هذه الحالات لوحظ أن الشريان الكعبري ينشأ من الشريان العضدي في الجهة الداخلية بالنسبة للشريان الزندي وفي الجزء الأسفل (البعيد) من العضد يعبر الشريان الكعبري على العصب الناصف معدلاً مساره إلى الجهة الوحشية ومستمرًا بها حتى يصل إلى اليد. وفي حالة واحدة (1.7%) رصد نشوء الشريان الكعبري والشريان الزندي من الشريان الإبطي بشكل مباشر في حين سجل غياب الشريان العضدي. وقد تم عمل دراسات إحصائية للحالات و تسجيل نسبة كل منها.

خاتمة: أظهرت الدراسة وجود اختلافات في التفرع الثنائي النهائي للشريان العضدي بالنسبة لعنق عظمة الكعبرة ويجب على الجراحين معرفة ذلك وذلك حين عمل أي تدخل جراحي في منطقة الشريان العضدي.

Objectives: To observe the topographic localization of the brachial artery termination.

Methods: This study was conducted at the Department of Anatomy, Faculty of Medicine, King Abdulaziz

University, Jeddah, Kingdom of Saudi Arabia from December 2011 to February 2013. The bifurcation level of the brachial artery was determined in relation to the neck of the radius. Normal and abnormal terminations of the brachial artery were recorded.

Results: In 13 cases (21.7%), the bifurcation of brachial artery was normal. In 33 cases (6%), the bifurcation level was a few centimeters below the neck of the radius. In 7 cases (11.7%), the bifurcation level was above the radial neck in the area of cubital fossa. In 6 cases (10%), the termination of the brachial artery was found to be above the middle of the front of the arm. In one of the previous cases, the radial artery arose from the brachial artery on the medial side of the ulnar artery. In one case (1.7%), the radial and the ulnar arteries originated directly from the axillary artery, the brachial artery was absent.

Conclusion: Morphological variations of the brachial artery are common findings and should be considered by surgeons when performing procedures in the brachial artery area.

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The brachial artery begins at the lower border of teres major muscle, as a continuation of the axillary artery. It provides the main arterial supply to the arm. It terminates opposite the neck of the radius by dividing into radial and ulnar arteries. The ulnar artery is the larger of the two main branches of the brachial artery, while the radial is the smaller branch.¹ Most authors, such as Krishnamurthy et al² and Bhat et al³ emphasized that accurate knowledge on the normal and abnormal variation of the upper limb blood vessels, in particular that of the brachial artery is of great importance in the surgical procedure in this region. Variations in the origin, branching, and course of the main arteries of the human upper limb are common, and have received the attention of anatomists and surgeons long time ago.⁴ The determination and knowledge of these variations are important for performing vascular and reconstructive surgery.⁵ Anatomical variations of the upper limb arteries have been reported during dissection of the cadavers and in clinical practice. The variation can occur at the level of axillary artery,⁶ brachial artery,⁷ radial artery,⁸ and ulnar artery,⁹ as well as the palmar arches.¹⁰ The ulnar artery must be patent before raising a free radial forearm flap. The patency of ulnar artery can be confirmed by Doppler flow meter. After this flap, the patency of ulnar artery will determine the blood supply of the hand completely. Subsequently, any anatomical variation of the ulnar artery is important in surgical and angiographic procedures linked to this region.⁹ Since the upper extremity is a frequent site of injury, various surgical and invasive procedures are performed in these regions. It is important for the surgeons and radiologists to be aware of the possible arterial variations in order to prevent complications during surgical and diagnostic procedures. Therefore, the aim of this study was to determine the exact site of the brachial artery bifurcation and its possible arterial variations.

Methods. In the present study, 60 brachial arteries of adult cadavers from the Department of Anatomy, Faculty of Medicine, King Abdulaziz University were used from December 2011 to February 2013. A search was performed in PubMed to find related studies. Ethical approval for conducting this study was obtained from the Faculty of Medicine of our institution.

Study design. The brachial arteries of adult cadavers were dissected to study the anatomical variations of brachial artery bifurcation. An incision of the middle of the front of the arm was performed. The skin was carefully dissected and reflected to expose the underlying structure. The subcutaneous fat and fascia were removed. The brachial artery was carefully

dissected from the surrounding structures. The artery was exposed and topographic localization of its site of bifurcation was estimated. The bifurcation level was determined in relation to the neck of the radius. The origins of the radial and ulnar arteries from brachial or axillary arteries were identified. Normal and abnormal terminations of the brachial artery was recorded and photographed.

Results. In the present study, the cubital fossa and the arm were dissected to examine the level of the bifurcation of the brachial artery. The study of 60 brachial arteries of adult cadavers revealed the following results: in 13 cases (21.7%), the brachial artery bifurcated normally into radial and ulnar branches at the level of the neck of the radius (Figure 1); in 33 cases (55%), there was mild deviation from the normal bifurcation level just few centimeters down the neck of radius, and the distance of bifurcation from the neck of the radius ranged from 0.4-1.8 cm (Figure 2); in 7 cases (11.7%), the bifurcation level was above the radial neck in the vicinity of cubital fossa. The distance of bifurcation from the neck of the radius ranged from 0.7-2.0 cm (Figure 3); in 6 cases (10%), the termination of the brachial artery was just above the middle of the front of the arm, the distance of bifurcation from the neck of the radius ranged from 15.8-17.5 cm (Figure 4). In one of the previous cases, it was found that the radial artery arose medial to the ulnar artery, whereas in the inferior third of the arm, it crossed over the median nerve and ran laterally in the forearm (Figure 5); and in one case (1.7%) a higher bifurcation was also observed where the radial and ulnar arteries originated directly from the axillary artery. The brachial artery was absent (Figure 6A). The radial artery in this case has a tortuous course, and was medial and superficial to the ulnar artery; in the distal third of the arm the radial artery crossed over the median nerve (Figure 6B), and ran laterally in the forearm (Figure 6C).

Discussion. The normal bifurcation of the brachial artery into radial and ulnar arteries occurs at the level of the neck of the radius.^{1,11} Anatomical variations of the arteries of the upper limbs have important clinical implication for surgeons performing procedures in this area.² Surgeons should be aware of the normal and abnormal variation of brachial artery and its termination before performing surgery in the arm area. Many variations and anomalies of the brachial artery were reported in the literature. Cavdar et al⁶ reported a variant of the branching of the axillary artery that has been rarely (0.12-3.2%) documented in the literature.

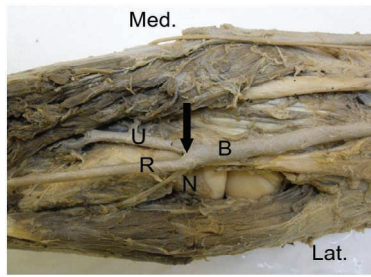


Figure 1 - A photograph of the front of the left cubital fossa showing the termination (arrow) of the brachial artery (B) opposite the neck of radius (N) by dividing into ulnar (U) and radial (R) arteries. Med - medial, Lat - lateral

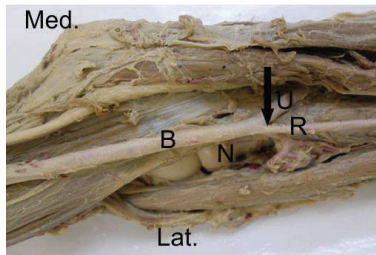


Figure 2 - A photograph of the front of the right cubital fossa showing the termination (arrow) of the brachial artery (B) below the neck of radius (N) by dividing into ulnar (U) and radial (R) arteries. Med - medial, Lat - lateral

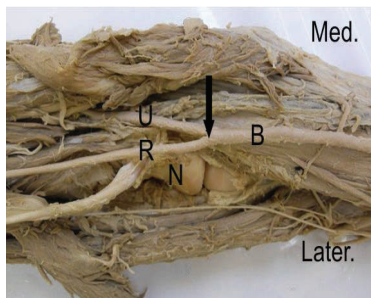


Figure 3 - A photograph of the front of the left cubital fossa showing the termination (arrow) of the brachial artery (B) above the neck of radius (N) by dividing into ulnar (U) and radial (R) arteries. Med - medial, Lat - lateral

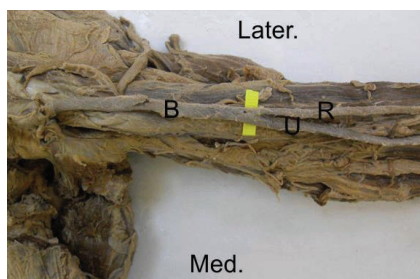


Figure 4 - A photograph of the front of the left arm showing the high origin of the ulnar (U) and the radial (R) arteries from the brachial artery (B). Med - medial, Lat - lateral

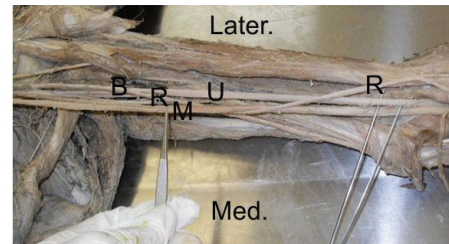


Figure 5 - A photograph of the front of the left arm showing the high origin of the ulnar (U) and radial (R) arteries from the brachial artery (B), the radial artery arising medial to the ulnar artery, whereas in the distal third of the arm it crosses over the median nerve (M) and runs laterally in the forearm. Med - medial, Lat - lateral

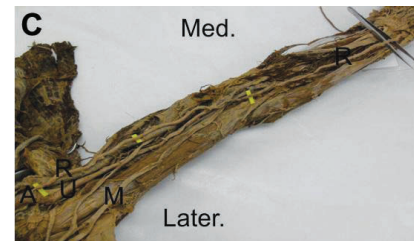
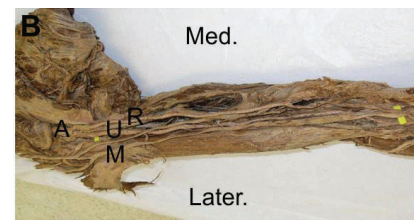
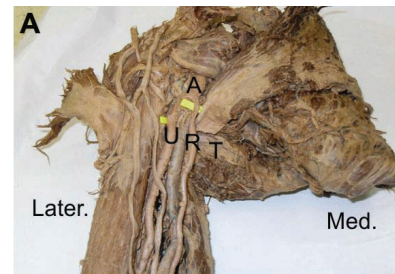


Figure 6 - A photograph of: A) right axilla and arm showing the high origin of the ulnar (U) and the radial (R) arteries from the axillary artery (A). Notice the teres major muscle (T); B) right upper limb showing the R and U originating from the A, the R has a tortuous course, and is medial and superficial to the U artery. In the distal third of the arm the R crosses over the median nerve (M); and C) right upper limb showing the R in the distal third of the arm crosses over the M, and then runs laterally in the forearm.

Bifurcation of the third part of the axillary artery into radial and brachio-ulnar arteries was reported by Patnaik et al.¹⁰ Yang et al¹² described the superficial brachial artery (SBA) as a branch of the axillary artery in 12.2% of cadaveric arms. Malcic-Gürbüz et al¹³

reported a unique case of trifurcation of the brachial artery into radial, ulnar, and superior ulnar collateral arteries high in the arm. Low divisions and trifurcation of the brachial artery was also reported by Vollala et al.⁷ Absence (agenesis or regression) of the brachial artery, a rare human variation of the upper extremity arterial anomalies, was reported by Ciervo et al.¹⁴ Natsis et al¹⁵ reported that the superficial ulnar artery (SUA) is an ulnar artery of high origin that lied superficially in the forearm. It originated from the right axillary artery at the level of the junction of the two median nerve roots. In the cubital fossa, it passed superficially over the medial side of the ulnar aponeurosis and coursed subcutaneously in the ulnar side of the forearm superficial to the forearm flexor muscles. The axillary artery arises from the SUA, and continued as brachial artery. The axillary artery terminated into the radial and common interosseous arteries in the cubital fossa. The regular ulnar artery was absent. Abnormal superficial ulnar arteries were reported bilaterally. The superficial ulnar artery rose from the axillary artery.¹⁶ Simic et al¹⁷ observed an anomalous origin of the superficial ulnar artery from the brachial artery approximately 6 cm distal to the profunda brachii artery. Yazar et al¹⁶ reported a rare case, in which the superficial ulnar artery originated from different sides on each side accompanied by anomalies of the palmar arches on one side. The ulnar artery originated from the axillary artery in one arm while it originated from the brachial artery at the level of the inter-epicondylar line on the other arm. Anatomical variations of radial artery have important implication for radiological and surgical procedures. The high origin of the radial artery was found to be the most common variation.⁸

In a case report by Okoro and Jiburum,⁵ an aberrant radial artery was seen arising from the anterior part of the axillary artery proximal to the union of the 2 roots of the median nerve in both upper limbs. This vessel continued into the arm medial to the brachial artery and median nerve. In the hand, it gave rise to the deep palmar and dorsal arches. The main brachial artery ended by dividing into the ulnar and common interosseous arteries. Bilateral variations of the high origin of the radial artery anomalies were found by Icten et al¹⁸ on the right side. The radial artery arose 2 cm above the junction of the 2 roots of the median nerve. On the left side, the radial artery arose from the brachial artery distal to the origin of the profunda brachii artery. The courses of these arteries in the forearm were normal.

In the present study, 47 cases (78.4 %) showed variations in the level of the brachial artery termination. While Krishnamurthy et al² found this variation in

18.5% only. Also, Natsis et al¹⁵ found this variation in 20% of human adult limbs. The most common variation in the present study was found in the vicinity of the cubital fossa. In 33 cases (55.7%), low level of the brachial artery termination below the radial neck was observed. Deviation from the normal level ranged from 0.4-1.8 centimeters. This is in comparison with the finding of Vollala et al⁷ regarding the termination of brachial artery, who reported low division of the brachial artery but giving trifurcation instead of bifurcation. On the other hand, in 7 cases (11.7%) the bifurcation of the brachial artery was found above the neck of the radius. The distance of bifurcation ranged from 0.7-2.0 cm from the neck of the radius.

Trifurcation of brachial artery as described by Vollala et al⁷ was not observed in the present studied samples, and seemed to be a rare anomaly. In the present study, 6 cases (10%) showed the high level of the brachial artery bifurcation above the middle of the front of the arm. The distance of the bifurcation of the brachial artery ranged approximately from 15.8 to 17.5 cm above the neck of the radius. This is in accordance with Krishnamurthy et al² who reported a high origin of the ulnar artery approximately 10 cm above the medial epicondyle. Devansh¹⁹ also reported high origin of the ulnar artery with an incidence of 9.38%. Latha et al²⁰ and Alameddine et al²¹ also reported similar findings, while Arora and Dada⁹ reported dual ulnar artery; the superficial ulnar arose from brachial artery at level of elbow joint and the deep ulnar artery took origin from axillary artery high up in the arm. Alameddine et al²¹ reported that the superficial position of the ulnar artery made it more vulnerable to trauma and hemorrhage, but at the same time more accessible for cannulation. Also they might be mistaken for veins. This could result in intra-arterial injections instead of intra-venous injections. This could also result in wrong reading of incomplete angiographic images. Hand irrigation could be interrupted during surgical procedures of the arm or the forearm. Bilateral high origin of the radial artery was reported by Icten et al,¹⁸ who observed that in the right side the radial artery arose 2 cm above the junction of the 2 roots of the median nerve. While on the left side, the artery arose from the brachial artery distal to the origin of the profunda brachii artery. A bilateral case of the superficial ulnar artery was reported by Yazar et al.¹⁶

In this study, the radial artery arose high in the upper arm but medial to the ulnar. In the distal third of the arm it crossed over the median nerve and ran laterally in the forearm. This findings is in accordance with Pelin et al,⁸ who described and evaluated an unusual course of the radial artery. They mentioned that the high origin of

the radial artery was the most frequent arterial variation observed in the upper limb, showing an incidence of 14.27% in dissection material and 9.75% in angiographic examination. The radial artery originated from the medial side of the brachial artery and crossed the median nerve twice in an unusual manner; 8 cm below the point, at which the deep brachial artery arose and 12 cm above the intercondylar line.

In the present study, the ulnar and the radial arteries originated from the axillary artery in only one case (1.7%). It could be considered a rare anatomical variation. The radial artery has a tortuous course and was medial and superficial to the ulnar artery. In the inferior third of the arm, the radial artery crossed over the median nerve, and then ran laterally in the forearm. This is in agreement with Patnaik et al¹⁰ who found that the axillary artery in its third part divided into 2 branches. One of these branches coursed superficial to the median nerve from the medial to the lateral side in the middle one third of the arm, and continued in the forearm as the radial artery. The other one gave off anterior and posterior circumflex humeral, subscapular, and profunda brachii branches. It coursed deep to the median nerve from the lateral to the medial side and continued in the forearm as the ulnar artery.

Due to the variations of the brachial artery, advised screening of such conditions by means of angiographic images and doppler ultrasound imaging, is of considerable importance during invasive and non-invasive investigative procedures; orthopedic, reconstructive or surgical procedures. The restricted number of cadavers available in our department was a limitation for this study. The anatomical variation of brachial artery and its termination obtained from this study could be of a great benefit for further various medical researchers in this area. Further studies could be carried out to investigate similar anomalies in the upper limbs.

In conclusion, anatomical variations of the brachial artery are common finding and the surgeons should consider them when performing procedures in brachial artery area.

References

1. Snell RS. Clinical Anatomy by Regions. 8th ed. Philadelphia (PA): Lippincott Williams and Wilkins; 2008. p. 475-505-528.
2. Krishnamurthy A, Madhan K, Soubhagya RN, Latha VP. High origin and superficial course of ulnar artery: a case report. *Firat Tip Dergisi* 2006; 11: 66-67.
3. Bhat KM, Potu BK, Gowda S. High origin of ulnar artery in south Indian male cadaver: A case report. *Rom J Morphol Embryol* 2008; 49: 573-575.
4. Yoshinaga K, Kodama K, Kameta K, Karasaqa N, Kanenaka N, Kohno S, et al. Rare variation of the arm artery: Coexistence with the superficial brachial and superficial arteries in the absence of the normal brachial artery. *Okajimas Folia Anat Jpn* 2003; 80: 23-28.
5. Okoro IO, Jiburum BC. Rare high origin of the radial artery: a bilateral, symmetrical case. *Nigerian Journal of Surgical Research* 2003; 5: 1-2.
6. Cavdar S, Zeybek A, Bayramicli M. Rare variation of the axillary artery. *Clin Anat* 2000; 13: 66-68.
7. Vollala VR, Nagabhooshana S, Bhat SM. Trifurcation of brachial artery with variant course of radial artery: rare observation. *Anat Sci Int* 2008; 83: 307-309.
8. Pelin C, Zagyapan R, Mas N, Karabay G. An unusual course of the radial artery. *Folia Morphol (Warsz)* 2006; 65: 410-413.
9. Arora L, Dada RR. Superficial ulnar artery: A case report. *Indian J Pract Doc* 2005; 2: 2005-2008.
10. Patnaik VVG, Kalsey G, Singla RK. Bifurcation of axillary artery in its 3rd part - a case report. *J Anat Soc India* 2001; 50: 166-169.
11. Moore KL, Agur AM. Artery of arm and forearm. Essential clinical anatomy 3rd ed. Baltimore (MD): Lippincott Williams and Wilkins; 2007. p. 439-455.
12. Yang HJ, Gil YC, Jung WS, Lee HY. Variation of the superficial brachial artery in Korean cadavers. *J Korean Med Sci* 2008; 23: 884-887.
13. Malcic-Gürbüz J, Gürnülüoglu R, Ozdogmuş O, Yalin A. Unique case of trifurcation of the brachial artery: its clinical significance. *Clin Anat* 2002; 15: 224-227.
14. Ciervo A, Kahn M, Pangilinan AJ, Dardik H. Absence of the brachial artery: report of a rare human variation and review of upper extremity arterial anomalies. *J Vasc Surg* 2001; 33: 191-194.
15. Natsis K, Papadopoulou AL, Paraskevas G, Totlis T, Tsikaras P. High origin of a superficial ulnar artery arising from the axillary artery: anatomy, embryology, clinical significance and a review of the literature. *Folia Morphol (Warsz)* 2006; 65: 400-405.
16. Yazar F, Kirici H, Ozan H, Aldur MM. An unusual variation of the superficial ulnar artery. *Surg Radiol Ana* 1999; 21: 155-157.
17. Simic P, Borovecki F, Jalsovec D, Jelic M, Martinovic S, Vinter I. The superficial ulnar artery originating from the left brachial artery. *Ital J Anat Embryol* 2004; 109: 13-18.
18. İçten N, Süllü Y, Tuncer I. Variant high-origin radial artery: a bilateral case. *Surg Radiol Anat* 1996; 18: 63-66.
19. Devansh MS. Superficial ulnar artery flap. *Plastic Reconstruct Surg* 1996; 97: 420-426.
20. Latha VP, Anuradha L, Narayana K. A case of superficial ulnar artery associated with retrobrachial median nerve. *Folia Anatomica* 2002; 30: 49-51.
21. Alameddine AK, Alimov VK, Engelman RM, Rousou JA, Flack JE 3rd, Deaton DW, et al. Anatomic variations of the radial artery: significance when harvesting for coronary artery bypass grafting. *J Thorac Cardiovasc Surg* 2004; 127: 1825-1827.