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ORIGINAL ARTICLE

# Branches of ulnar artery in human fetuses: anatomical and morphometric study

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## Abstract

**Purpose** This study was conducted to demonstrate morphological pattern of the ulnar artery and to evaluate morphometrically its anatomical branching pattern in human fetuses.

**Methods** Branching pattern of ulnar artery was evaluated on 121 upper limbs of dissected 63 of formalin-fixed fetus cadavers with gestational age ranging from 17 to 40 weeks. In order to obtain second and third trimester data, according to their gestational age, two groups were determined.

**Results** In 79 of all 121 upper limbs (65%) ulnar artery gave anterior and posterior ulnar recurrent arteries as separate branches. In this study frequency of presence of a median artery was 46.28% among total examined 121 upper limbs. Median arteries originated from ulnar artery (3.57%) and from the common interosseous artery (53.57%) and anterior interosseous artery (42.85%). Mean distances of the measured parameters were demonstrated according to the gestational age and differences between group I (second trimester) and group II (third trimester). No statistical difference for groups was observed for gender and between right and left sides.

**Conclusions** Ulnar artery shows predictable patterns during second and third trimester of fetal period and can be suitable access effective alternative for diagnostic and therapeutic coronary interventions. Persistent median artery is important variation and knowledge of its incidence is important for diagnostic difficulties and also during awareness of its injury during surgical approaches.

**Keywords** Ulnar artery · Branching pattern · Anatomy · Fetus · Median artery

## Introduction

Many variations have been reported about arteries of the upper limb [1, 5, 23, 26]. Study of Rodriguez-Niedenfuhr et al. [32] demonstrated that there are no significant differences between the embryonic and adult arterial variations. Additionally, Kopuz et al. [21] concluded that occurrence of persistent median artery was with remarkably higher rate in neonatal cadavers than in adult cadavers. In classical sources ulnar artery was reported more variable in its position than the radial artery [4]. The ulnar artery, the larger terminal branch of the brachial artery starts 1 cm distal to the flexion crease of the elbow in adults. In the forearm the artery initially lies on brachialis and deep to pronator teres and is covered by the skin, superficial and deep fasciae. The ulnar nerve lies medially to the distal two-thirds of the artery, which supplies the nerve throughout its length. In forearm it gave anterior and posterior ulnar recurrent arteries and common interosseous artery. This short branch just after its origin usually gives off a slender median artery [27, 38]. The ulnar recurrent adipofascial flap is an easy and reliable option for one stage reconstruction of massive defects around the elbow [15]. Posterior ulnar recurrent artery supplies the distal pedicled medial upper arm flap used to cover large elbow defects [30, 31]. The median artery (arteria comitans nervi mediani, median arter—according to Terminologia Anatomica 1998) is a relatively common anatomical variation [10, 17, 33] and the incidence of persistent median artery varies from 0.6 [2] to 81.25% [3]. In

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a previous report of a sample of 60 neonates and infants from South African new-borns and infants high frequency (44.2%) of the median artery of the forearm was reported [11]. It was stated in Bergman et al. [4] that the incidence was on average about 8%. The origin of the median artery in its antebrachial pattern was most frequently directly from the anterior interosseous artery [33]. Then common interosseous artery split into the anterior and posterior interosseous arteries. The posterior interosseous artery is usually smaller than the anterior interosseous artery. Additionally, posterior interosseous recurrent artery leaves the posterior interosseous artery near its origin. Based on this artery and venous branches, posterior interosseous artery flap is widely used for reconstructing of the forearm and proximal part of the hand. Knowledge of arterial variations of ulnar artery has a number of important implications for medical practice, but there is scant information regarding its embryological morphological branching pattern. Variations and morphological pattern of ulnar artery branching and their topographical relation may be important for inadvertent injury during preparations of free forearm flap and may also confuse the evaluation of angiographic images [16, 39]. Despite its obvious clinical importance, there is only few reports regarding its development and how or when during these variations arise. In order to increase our current understanding regarding development and variations of the ulnar artery and its branches, more data about ulnar artery morphological pattern in human fetuses is needed. The aim of this study was to establish the morphometry and anatomical branching pattern of ulnar artery in human fetuses.

## Materials and methods

The study was carried out on 63 formalin-fixed fetus cadavers with gestational age ranging from 17 to 40 weeks. Dissections of fetus cadavers were performed in the Department of Anatomy Laboratory of the Gulhane Medical Faculty, and the rest were performed in the Department of Anatomy Laboratory of the Mersin University Faculty of Medicine. Fetuses from Mersin University Faculty of Medicine were provided from the Pathology Laboratory of the Faculty of Medicine of Mersin University with the permission of the ethical committee. Fetuses from Gulhane Medical Faculty were medicolegally obtained from Ankara Maternity and Health Academic and Research Hospital. All data about the gestational age of the fetuses were collected from the hospital. Permission to conduct this study was obtained from the local ethics committee of Gulhane Military Medical Academy. Branching pattern of ulnar artery was evaluated on 121 upper limbs. In order to obtain second (14–26 week) and third trimester (27–40 week), data two groups were determined. According to their gestational age, in group I (17–26 gestational week) 80 extremities and in group II (27–37 gestational week) 41 extremities were evaluated.

For dissections surgical microscope Carl–Zeiss OPMI1-FR was used. After longitudinal incision of cubital fossa superficial dissection was performed and adipose tissue and fascial layers were removed. After dissection of median nerve and brachial artery, bifurcation point of brachial artery and radial and ulnar artery and their branching patterns were exposed. Morphological branching pattern of ulnar artery was evaluated and variations such as median artery were noted. Following parameters were measured:

A: distance between point where anterior recurrent ulnar artery originated and bifurcation point of brachial artery,
B: distance between point where posterior recurrent ulnar artery originated and bifurcation point of brachial artery,
C: distance between point where common recurrent ulnar artery originated and bifurcation point of brachial artery,
D: distance between point where common interosseous artery originated (or the point where its proximal branch originated) and bifurcation point of brachial artery.

Measured distances were performed using digital caliper. Data analysis was performed using SPSS 16.0 program. Comparisons of the measurements according to gender and between groups were performed using an independent samples *t* test. A paired samples *t* test was used to compare the measurements of right versus left sides.

## Results

In all cases brachial artery was divided at the neck of the radius to radial and ulnar artery and all branches of the ulnar artery were observed. In 79 of all 121 upper limbs (65%) ulnar artery gave anterior and posterior ulnar recurrent arteries as separate branches (Figs. 1a, 2c). In rest 42 (35%) upper limbs anterior and posterior ulnar recurrent arteries were originated as a single trunk (Fig. 1b).

The distance (A) between origin of the anterior recurrent ulnar artery and the bifurcation point of brachial artery during second trimester was $2.54 \pm 0.77$ mm and $2.59 \pm 0.88$ mm for right and left sides consequently, and during third trimester was $3.4 \pm 2.05$ mm and $4.7 \pm 2.63$ mm (for right and left sides). The distance (B) between origin of the posterior recurrent ulnar artery and the bifurcation point of brachial artery during second trimester was $4.12 \pm 01.61$ mm and $3.78 \pm 1.1$ mm for right and left sides consequently, and during third trimester was $6 \pm 1.62$ mm and $6.8 \pm 2.7$ mm (for right and left sides) (Fig. 2a). The distance (C) between origin of the common recurrent ulnar artery (Fig. 2b) and the bifurcation point of brachial artery during second trimester

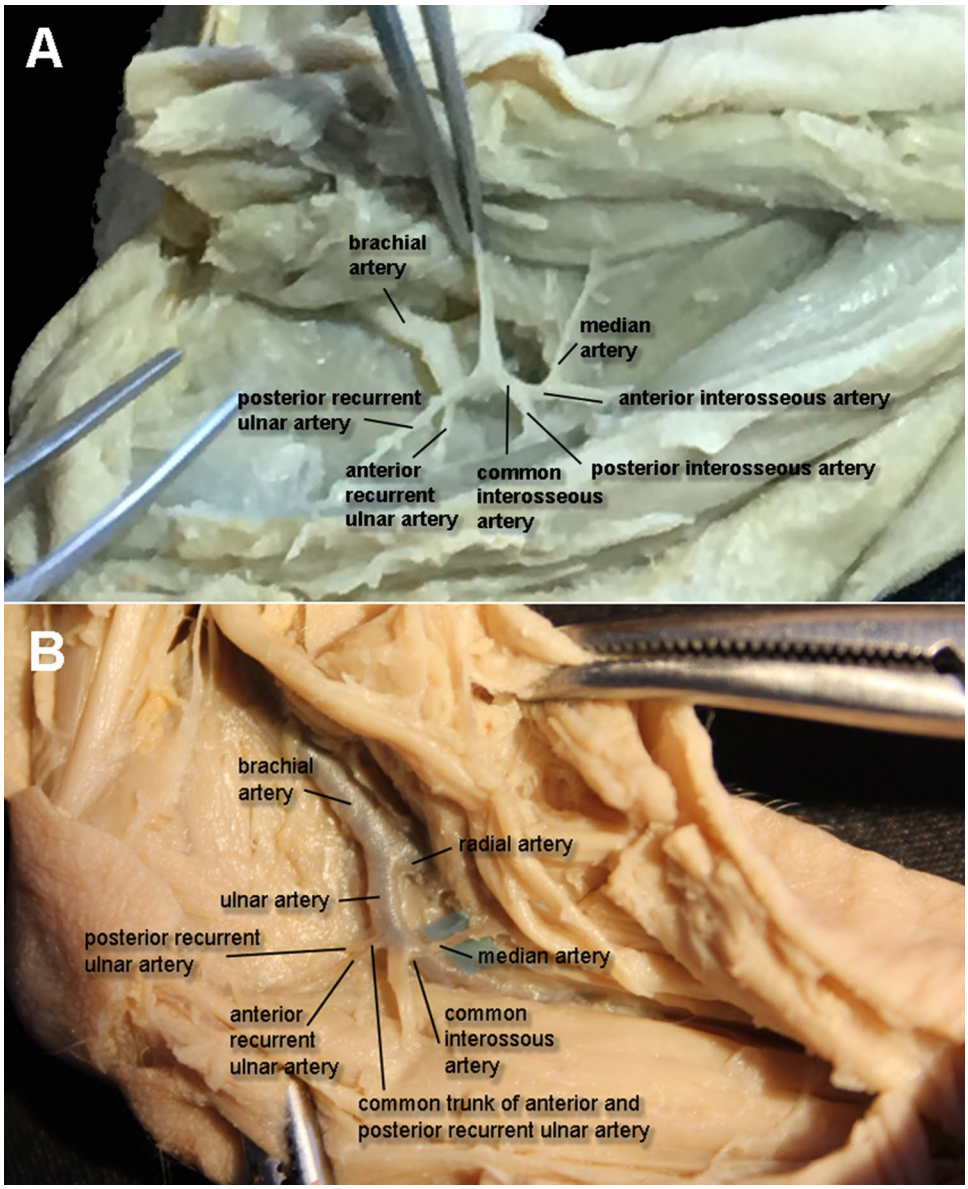


**Fig. 1** **a** Ulnar artery gave anterior and posterior ulnar recurrent arteries as separate branches and median artery stemmed directly from the anterior interosseous artery. Left upper limb. **b** Anterior and posterior ulnar recurrent arteries were originated as a single trunk and median artery stemmed from the common interosseous artery. Left upper limb

was $4.29 \pm 1.27$ mm and $3.77 \pm 1.29$ mm for right and left sides consequently, and during third trimester was $4.51 \pm 2.94$ mm and $3.98 \pm 1.06$ mm (for right and left sides). The distance (D) between origin of the common interosseous artery and the bifurcation point of brachial artery during second trimester was $5.42 \pm 1.59$ mm and $5.21 \pm 1.29$ mm for right and left sides consequently, and during third trimester was $7.15 \pm 2.34$ mm and $7.53 \pm 2.16$ mm (for right and left sides) (Fig. 2c).

Mean distances of the measured A, B, C, D parameters according to the gestational age and differences between group I (second trimester) and group II (third trimester) was shown in Table 1. There were no statistically significant differences between group means for right and left sides and for gender.

In 56 cases of 121 upper limbs (2nd and 3rd trimester) forearm type of median artery (arteria comitans nervi mediani antebrachii) originated from various sites: it can be directly from the ulnar artery (only in two cases and unilaterally) (Fig. 3a), from anterior interosseous artery (in 24 cases) (Figs. 1a, 3b) and from common interosseous artery (in 30 cases) (Figs. 1b, 2a). In this study frequency of presence of a median artery was 46.28%. Median arteries originated from ulnar artery (3.57%), from the common interosseous artery (53.57%) and anterior interosseous artery (42.85%). Comparison of literature with the results of present study, as their sample numbers, frequency, and origin of median artery, was shown in Table 2 [3, 17, 18, 21, 22].

In two upper limbs anterior interosseous artery and posterior interosseous artery originated from ulnar artery as

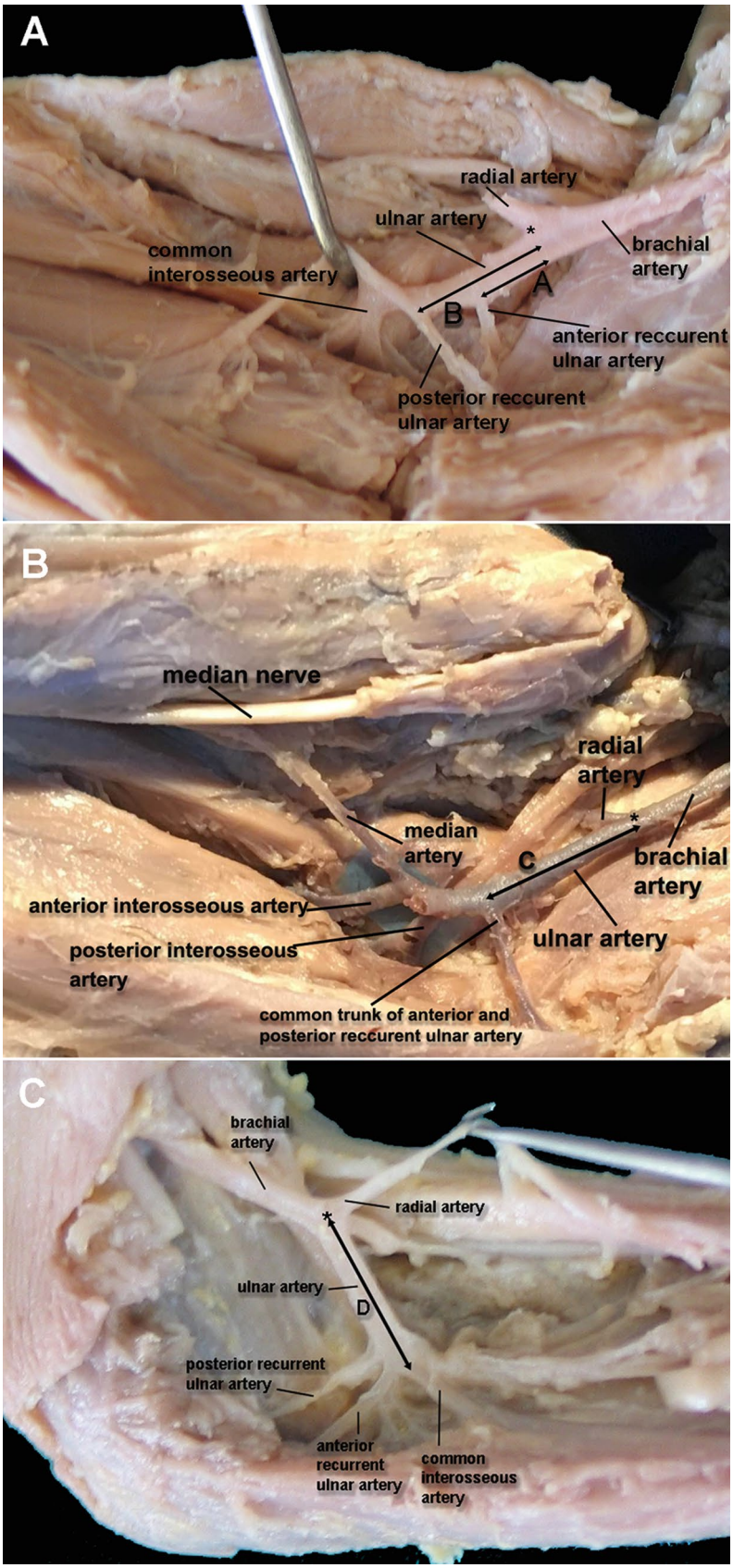


**Fig. 2** In this picture measured distances (A, B, C, D) were demonstrated. **a** Right upper limb. A: Distance between point where anterior recurrent ulnar artery originated and bifurcation point of brachial artery. B: Distance between point where posterior recurrent ulnar artery originated and bifurcation point of brachial artery. **b** In this right upper limb anterior interosseous artery and posterior interosseous artery originated from ulnar artery as separate branches, additionally median artery stemmed from the common interosseous artery. C: Distance between point where common recurrent ulnar artery originated and bifurcation point of brachial artery. **c** In a left upper limb anterior and posterior ulnar recurrent arteries originated as separate branches. D: Distance between point where common interosseous artery originated (and the point where its proximal branch originated) and bifurcation point of brachial artery

**Table 1** According to the gestational age and differences between group I (second trimester) and group II (third trimester) parameters A–D were demonstrated

| | 2. trimester (mm) | 3. trimester (mm) |
|---|---|---|
| A: ARUA-BBA | | |
| Right | 2.54 ± 0.77 | 3.4 ± 2.05 |
| Left | 2.59 ± 0.88 | 4.7 ± 2.63 |
| B: PRUA-BBA | | |
| Right | 4.12 ± 01.61 | 6 ± 1.62 |
| Left | 3.78 ± 1.1 | 6.8 ± 2.7 |
| C: CR-BBA | | |
| Right | 4.29 ± 1.27 | 4.51 ± 2.94 |
| Left | 3.77 ± 1.29 | 3.98 ± 1.06 |
| D: CI-BBA | | |
| Right | 5.42 ± 1.59 | 7.15 ± 2.34 |
| Left | 5.21 ± 1.29 | 7.53 ± 2.16 |

*ARUA* origin of the anterior recurrent ulnar artery, *PRUA* origin of the posterior recurrent ulnar artery, *BBA* bifurcation point of brachial artery, *CR* origin of the common recurrent ulnar artery, *CI* origin of the common interosseous artery

separate branches (Fig. 2b). Common interosseous artery (Fig. 3b) originated from the ulnar artery as a short trunk in 119 (119 of 121) upper limbs and then splits into the anterior and posterior interosseous branches at the upper border of interosseous membrane of the forearm. Additionally, in one upper limb (in a fetus with 37 week of gestation) there was a variation where posterior recurrent ulnar artery left the posterior interosseous artery (Fig. 3c).

## Discussion

Variations in arterial patterns in the upper limb has high incidence of and this is important for clinicians and anatomists. Regarding these variant patterns of the arm and forearm previously used variable terminology was unified with 12 categories [34]. Additionally, in a previously published review regarding the embryological theories about the development of the arterial pattern and its variations it was mentioned that there are no significant differences between the embryonic and adult samples [32]. Haerle et al. concluded that the ulnar artery is rarely dominant at the forearm level and is physiologically less important [14]. Additionally, it was mentioned that there is no hemodynamic reason to prefer the radial artery to the ulnar artery for flaps.

Plastic surgeons discuss about advantages of the ulnar artery forearm island flap in hand surgery over the radial island forearm flap [13]. Some advantages as easy of donor site repair, cosmetic acceptability, and hairlessness were mentioned [6]. Additionally, it was discussed that the arterial and venous anatomy of the ulnar artery forearm flap, as a reliable, versatile and convenient fasciocutaneous flap, permits its use as a distally pedicled island flap [24]. The posterior interosseous artery only supplies the proximal half of the forearm and provides vascular basis for proximally based flaps [19]. In present study interosseous arteries originated as common interosseous artery in 119 of 121 upper limbs. Bifurcation point of brachial artery to radial and ulnar arteries normally is between the intercondylar line of the humerus and the head of the radius [38]. A superficial ulnar artery is an ulnar artery of high origin that lies superficially in the forearm. Its reported frequency ranges from 0.17 to 2% [28]. Another study reported its prevalence prevalence of 0.7–9.4% [37] and presence of this artery was recommended as easy and safe alternative in reconstructive fasciocutaneous forearm flaps and its presence should be considered during flap harvesting. In present study we did not find this variation. Vollala et al. reported a case with high origin of ulnar artery [41], however, in this study of 121 upper limbs any case with high origin of ulnar artery was not found. Case with left superficial brachial artery continued as superficial radial artery was reported in a fetus [42]. Ulnar artery can be suitable access for coronary angiography to the significant risks of femoral access and is occasionally used as an alternative as transulnar approach as a safe and effective alternative for diagnostic and therapeutic coronary interventions. Previous study of Gokhroo et al. concluded that transulnar access is a safe and also an effective alternative to transradial access in terms of feasibility and safety [12]. Roberts et al. reported success of transulnar procedure as 90.9% [31]. Ulnar artery absence is a rare variation and has not been reported by previous authors. Only there is one reported case about the absence of the ulnar artery, responsible for hand ischemia after radial artery grafting [29]. This morphological feature was not found in this study. According to the embryological basis it was mentioned that normal brachial artery which continues in the forearm as the common interosseous trunk will gave off the radial recurrent and ulnar recurrent arteries. Then ulnar artery gives anterior and posterior interosseous arteries. In present study pattern all it was found as in normal ulnar artery pattern sending off the ulnar recurrent artery and ending in the hand. Only in 42/121 limbs of fetuses anterior and posterior ulnar recurrent arteries were originated as a single trunk, in the others were as separate branches. Others (65%) were originated as separate branches and this was parallel to the embryological basis and explains the standard separate pattern of anterior and posterior ulnar recurrent arteries in adults.

According to previous study [20] median artery regresses progressively and disappears during post fetal life. Median artery may persist into adulthood and varies from 0.6 [2] to 81.25% in adult populations and may contribute significantly towards formation of the superficial palmar arch [3]. In this case it will support functionality of the interosseous artery

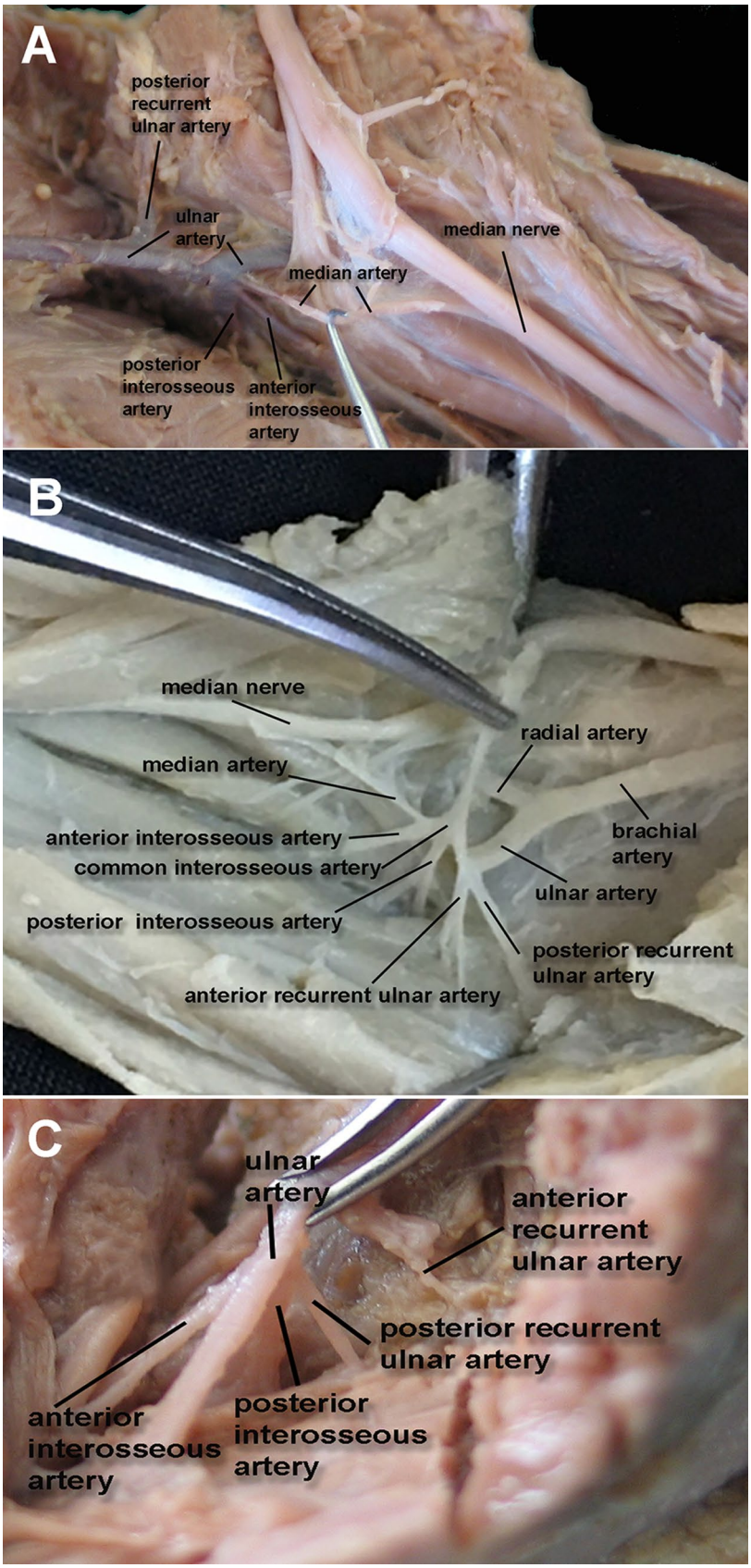


**Fig. 3** Demonstrative cases with different branching pattern and different origin of the branches of the ulnar artery. **a** Median artery unilaterally directly originated from the ulnar artery. Left upper limb. **b** Common interosseous artery was originated as short trunk and median artery stemmed directly from the anterior interosseous artery. Right upper limb. **c** In this picture variation in which posterior recurrent ulnar artery originated from the posterior interosseous artery was demonstrated. Right upper limb

**Table 2** Literature summary regarding median artery and its comparison with results of this study was demonstrated

| Authors | Sample | Incidence | Percentage | Specimen cadavers | UA | CIA | AIA |
|---|---|---|---|---|---|---|---|
| Kopuz et al. [22] | 110 | 5 | 4.5% | Neonatal | 4 | 1 | na |
| Kopuz et al. [21] | 60 | 12 | 20% | Neonatal | 8 | 4 | na |
| Henneberg and George [18] | 120 | 53 | 44.2% | Neonatal, infant | na | na | na |
| Aragão et al. [3] | 32 | 26 | 81.25% | Fetuses | 5 | 10 | 9 |
| Present study | 121 | 56 | 46.28% | Fetuses | 2 | 30 | 24 |

*AIA* anterior interosseous artery, *CIA* common interosseous artery, *UA* ulnar artery, *na* not available

[8, 35, 40]. In embryonal, neonatal and pediatric populations it can be in high frequency [7, 17, 21–23, 25, 34, 35]. But also early as the 8th week of intrauterine life its regression may occur [9, 36]. Table 2 demonstrates findings of this study for median artery, as their sample numbers, frequency, and its origin and their comparison of with previous literature. In present study presence of a median artery was 46.28%, and it was parallel to the previous literature.

## Conclusions

Ulnar artery is good alternative for flaps, can be suitable access for coronary angiography and its absence is a rare variation, therefore its morphological pattern and its embryological basis is important. Morphometrically parameters show that during its development ulnar artery and its branches did not present many variations and shows predictable relations and patterns during second and third trimester of fetal period. Anterior and posterior ulnar recurrent arteries originate in %65 as separate branches and support embryological basis of standard separate pattern. Persistent median artery is important variation and knowledge of its incidence is important for diagnostic difficulties and during awareness of its injury during surgical approaches to the carpal tunnel syndrome. Persistent median artery accompanies the median nerve along its course and is clinically relevant with anterior interosseous nerve syndrome, pronator teres syndrome, and ischemia of the hand and during diagnosis its persistence should be taken into consideration.

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**Author contributions** SY, NK, AC designed this study; SY, OE and AC performed anatomical dissections; NK and BY analyzed the data; SY and AC wrote the manuscript.

## Compliance with ethical standards

**Conflict of interest** None of the authors have any conflict of interest with the content of this manuscript.

**Disclaimer** None.

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