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Anatomical and morphometric features of the profunda brachii artery

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Abstract: When the literature is examined, studies evaluating the profunda brachii artery (PBA) are limited as most studies only investigate the artery's origin. In 44 upper extremities belonging to 24 human anatomical specimens, single and double PBAs were observed in 39 and five cases, respectively. In cases with a single PBA, the origin was the brachial artery (BA) in 35 cases and the posterior circumflex humeral artery in four cases. In cases with double PBAs, the artery's origin was the BA. Morphometric measurements of single and double arteries originating from the first branch BA were evaluated separately and compared according to sex and side. Our study, in which the PBA was examined morphologically and morphometrically, contributes to the literature anatomically and radiologically in treating humerus fractures and lateral arm-flap applications by surgeons.

Key words: Profunda brachii artery, Morphology, Morphometry, Human anatomical specimen, Brachial artery

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Introduction

The axillary artery is called the BA after it passes the lower border of the teres major. The BA is located at the proximal part of the arm, at the medial side of the humerus, and between the triceps brachii and the coracobrachialis muscles. As it continues to the distal, it is located in front of the humerus and between the biceps brachii and brachialis muscles. When the BA passes the elbow joint, it divides into two terminal branches, the radial artery and the ulnar artery. Along the arm, the BA is accompanied by two brachial veins [1-4].

The profunda brachii artery (PBA) is the first and thickest branch of the BA, branching from the posteromedial side of the BA. It continues between the lateral and the medial heads of the triceps brachii and courses along the radial nerve in the radial groove, extending up to the elbow level. After providing branches that feed the muscles and humerus along its path, it ends by dividing into the middle collateral artery and radial collateral artery [1-3].

Knowledge of the normal and variable anatomy of the arterial distribution of the human upper limb is essential for surgery and angiography. However, after having searched the literature, an insufficient number of studies about the PBA's origin, number, and branching variations were found. Branching variations can cause excessive bleeding in humeral fractures and iatrogenic injuries during arterial catheterization [5-9].

A review of other studies showed that the term "deep brachial artery" is also used when referring to the PBA [10]. According to anatomical terminology, the Latin term "profunda brachii artery" is used; however, in clinical practice and in several English medical sources, the term "deep brachial artery" is also utilized. Both terms refer to the same structure.

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Materials and Methods

In order to examine the PBA, 44 upper extremities of 24 (7 female, 17 male) human anatomical specimens used in the instruction of medical students between 2006 and 2020 were used at Istanbul University's Faculty of Medicine, Department of Anatomy. Morphological evaluation was performed bilaterally in 20 human anatomical specimens and unilaterally in four human specimens (44 sides; 21 right and 23 left). Two cadavers (4 sides) were excluded from the study because arterial integrity was not preserved. Morphometric measurements were made bilaterally in 16 human anatomical specimens and unilaterally in eight human specimens (40 sides; 19 right and 21 left). Morphometric measurements were not performed on four PBAs with a variation of the place of origin (four sides; two right and two left). The mean age of the human specimens was calculated as 69.55±9.47 (minimum: 48; maximum: 89). Measurements were made repeatedly by one person, and two observers monitored the measurement collection.

Approval was obtained from the Ethics Committee of Istanbul University. The procedures used in this study adhere to the tenets of the Declaration of Helsinki (23.11.2020/202324).

Morphological evaluation

Numerical variations of the PBA (single or double) (Fig. 1) and variations of origin (PBA originating from different arteries) (Fig. 2) were examined.

Morphometric evaluation

Regarding morphometric evaluation, ten morphometric measurements were made using a digital caliper (Mitutoyo). Measurements in double PBA cases were made according to the proximal origin branch of the double PBA (PBA^1) (if the distal origin branch of double PBA is abbreviated as "PBA^2").

1. The shortest distance between the apex of the caput humeri (CH) and the most protruding part of the lateral epicondylitis of the humerus to assess the arm length (AL) (Fig. 3).

2. The shortest distance between the most protruding point of processus coracoideus of the scapula and the origin of the PBA (Fig. 3).

3. The shortest distance between the apex of CH and the origin of the PBA (Fig. 3).

4. The shortest distance between the origin of the last branch of the axillary artery and the origin of the PBA (Fig. 3).

5. In case the first branch of the BA (FBBA) is a branch other than the PBA: the shortest distance between the origin of the FBBA and the origin of the PBA ($FBBA^1$-PBA) (Fig. 4).

6. If the FBBA is PBA: the shortest distance between the origin of the PBA and the origin of the FBBA after the PBA

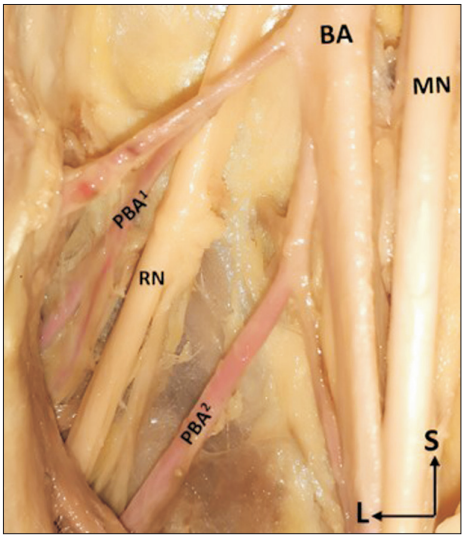

Fig. 1. Double profunda brachii artery (PBA) cases of the brachial artery (BA) origin (right) (front view). MN, median nerve; RN, radial nerve.

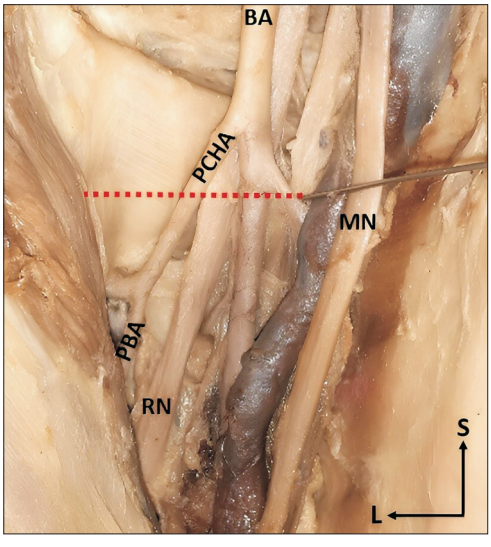

Fig. 2. Profunda brachii originating from the posterior circumflex humeral artery (PCHA) (right) (front view). The red dotted line indicates the lower limit of the teres major. BA, brachial artery; PBA, profunda brachii artery; MN, median nerve; RN, radial nerve.

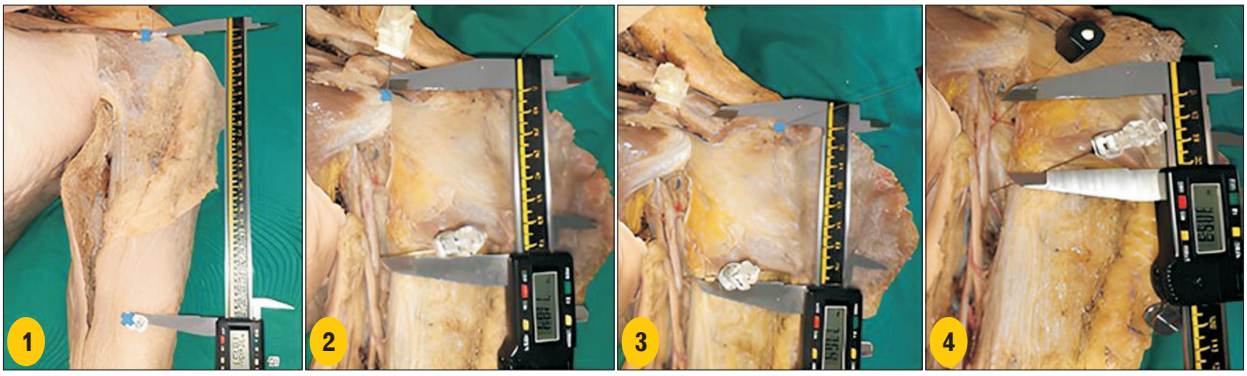

Fig. 3. Measurements numbered "1, 2, 3, 4" for morphometric evaluation and reference points used in these measurements (left) (front view).

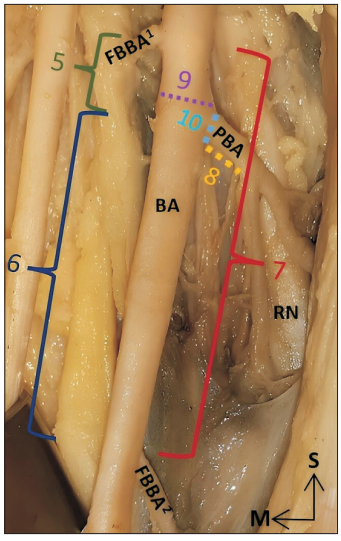

Fig. 4. Measurements numbered "5, 6, 7, 8, 9, 10" for morphometric evaluation and reference points used in these measurements (left) (front view). FBBA, first branch of the brachial artery; PBA, profunda brachii artery; BA, brachial artery; RN, radial nerve.

(PBA-FBBA^2) (Fig. 4).

7. In case the FBBA is a branch other than the PBA: the shortest distance between the origin of the FBBA and the origin of the FBBA after the PBA (FBBA^1-FBBA^2) (Fig. 4).

8. The shortest distance between the origin of the first branch of PBA (FBPBA) and the origin of PBA (FBPBA-PBA) (Fig. 4).

9. The outer diameter of the BA where it gives the PBA (Fig. 4).

10. The outer diameter of PBA at the place of origin (Fig. 4).

Table 1. Numerical and origin location variations of profunda brachii artery in our study

Numerical variations	Origin location (n=44)	
	BA	PCHA
Single PBA (39 extremities)	35 (79.55)	4 (9.09)
Double PBA (5 extremities)	5 (11.36)	-

Values are presented as number (%). BA, brachial artery; PCHA, posterior circumflex humeral artery; PBA, profunda brachii artery.

Results

The arteria profunda brachii of 44 extremities were examined in our study. It was observed as single in 39 (88.64%) cases and double in five cases (11.36%; unilateral in three human anatomical specimens and bilateral in one). The PBA was examined in 44 extremities, 40 of which (90.91%) originated in the BA and four (9.09%) in the posterior circumflex humeral artery (PCHA). Four PBAs had origin variation (4 extremities-9.09%), two originated in the PCHA (unilateral in two human anatomical specimens) originating in the third part of the axillary artery, and the remaining two originated in the PCHA (unilateral in two human anatomical specimens), arising from the BA (Table 1).

In this study, 16 human anatomical specimens were examined bilaterally, and eight human anatomical specimens were examined unilaterally in the morphometric measurements of the PBA (40 sides; 19 right and 21 left) (Table 2). In terms of sex, the human specimens consisted of seven females and 17 males. Morphometric measurements were not performed in the PBA at four extremities with origin variation.

The morphometric measurements of single PBAs (29 extremities) originating from the BA as the first branch were evaluated separately; these measurements are summarized in Tables 3 and 4.

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Table 2. The minimum, maximum, mean and standard deviation values of the parameters measured in single profunda brachii artery, the first branch of brachial artery

Parameters	Number of extremities	Min. (mm)	Max. (mm)	Mean (mm)	SD (mm)
AL	29	252.2	319.4	289.9	17.5
PC-PBA	29	58.9	108.0	90.0	12.2
CH-PBA	29	68.1	117.3	99.0	13.2
LBAA-PBA	29	16.3	59.4	40.0	7.7
PBA-FBBA^2	29	3.9	62.2	27.3	14.3
FBPBA-PBA	29	1.6	28.0	8.7	5.9
DBA	29	4.6	7.4	5.7	0.7
DPBA	29	1.6	3.8	2.5	0.6

P<0.05 was considered significant. The abbreviation "ABID^1", which expresses the case that the first branch of the brachial artery (FBBA) is a different branch from the profunda brachii artery (PBA), the abbreviation "ABID^2" is used to indicate the FBBA after the PBA. Min., minimum; Max., maximum; SD, standard deviation; AL, arm length; PC-PBA, the shortest distance between the most protruding point of processus coracoideus (PC) of the scapula and the origin of PBA; CH-PBA, the shortest distance between the apex of caput humeri (CH) and the origin of PBA; LBAA-PBA, the shortest distance between the origin of the last branch of axillary artery (LBAA) and the origin of PBA; PBA-FBBA^2, the shortest distance between the origin of PBA and the origin of the FBBA^2 after PBA; FBPBA-PBA, the shortest distance between the origin of the first branch of PBA (FBPBA) and the origin of PBA; DBA, the outer diameter of the brachial artery (BA) where it gives the PBA; DPBA, outer diameter of PBA at the place of origin.

Table 3. Comparison of single profunda brachii artery the first branch of brachial artery in this study by sex

Parameters	Number of extremities	Famale (n=7)			Male (n=22)			P
		Min. (mm)	Max. (mm)	Mean (mm)	Min. (mm)	Max. (mm)	Mean (mm)	
AL	29	252.2	289.2	276.1	262.2	319.4	294.3	<0.001
PC-PBA	29	58.9	94.2	85.5	73.3	108.0	94.2	<0.001
CH-PBA	29	68.1	102.7	76.8	78.5	117.3	103.3	<0.001
LBAA-PBA	29	16.3	43.7	34.5	26.3	59.4	41.8	0.028
PBA-FBBA^2	29	8.1	47.0	27.8	3.9	62.2	27.1	0.922
FBPBA-PBA	29	1.6	20.0	11.0	2.5	28.0	8.0	0.259
DBA	29	4.9	6.6	5.7	4.6	7.4	5.7	0.874
DPBA	29	1.7	3.7	2.6	1.6	3.8	2.5	0.577

P<0.05 was considered significant. The abbreviation "ABID^1", which expresses the case that the first branch of the brachial artery (FBBA) is a different branch from the profunda brachii artery (PBA), the abbreviation "ABID^2" is used to indicate the FBBA after the PBA. Min., minimum; Max., maximum; AL, arm length; PC-PBA, the shortest distance between the most protruding point of processus coracoideus (PC) of the scapula and the origin of PBA; CH-PBA, the shortest distance between the apex of caput humeri (CH) and the origin of PBA; LBAA-PBA, the shortest distance between the origin of the last branch of axillary artery (LBAA) and the origin of PBA; PBA-FBBA^2, the shortest distance between the origin of PBA and the origin of the FBBA^2 after PBA; FBPBA-PBA, the shortest distance between the origin of the first branch of PBA (FBPBA) and the origin of PBA; DBA, the outer diameter of the brachial artery (BA) where it gives the PBA; DPBA, outer diameter of PBA at the place of origin.

Table 4. Comparison of single profunda brachii artery the first branch of brachial artery in our study by side (right and left)

Parameters	Number of extremities	Right (n=15)			Left (n=14)			P
		Min. (mm)	Max. (mm)	Ort. (mm)	Min. (mm)	Max. (mm)	Ort. (mm)	
AL	29	266.7	319.4	292.5	252.2	319.4	287.1	0.424
PC-PBA	29	70.0	108.0	92.1	58.9	103.9	87.7	0.335
CH-PBA	29	76.4	117.3	101.7	68.1	109.7	96.1	0.258
LBAA-PBA	29	26.3	59.4	42.4	16.3	45.5	37.4	0.0083
PBA-FBBA^2	29	3.9	62.2	24.9	8.1	43.3	29.9	0.360
FBPBA-PBA	29	2.8	28.0	9.3	1.6	20.0	8.0	0.560
DBA	29	4.6	7.4	5.8	4.6	6.6	5.5	0.193
DPBA	29	1.7	3.8	2.5	1.6	3.7	2.5	0.869

P<0.05 was considered significant. The abbreviation "ABID^1", which expresses the case that the first branch of the brachial artery (FBBA) is a different branch from the profunda brachii artery (PBA), the abbreviation "ABID^2" is used to indicate the FBBA after the PBA. Min., minimum; Max., maximum; Ort., Mean (mm); AL, arm length; PC-PBA, the shortest distance between the most protruding point of processus coracoideus (PC) of the scapula and the origin of PBA; CH-PBA, the shortest distance between the apex of caput humeri (CH) and the origin of PBA; LBAA-PBA, the shortest distance between the origin of the last branch of axillary artery (LBAA) and the origin of PBA; PBA-FBBA^2, the shortest distance between the origin of PBA and the origin of the FBBA^2 after PBA; FBPBA-PBA, the shortest distance between the origin of the first branch of PBA (FBPBA) and the origin of PBA; DBA, the outer diameter of the brachial artery (BA) where it gives the PBA; DPBA, outer diameter of PBA at the place of origin.

Discussion

This study was performed in a total of 44 upper extremities, and the rate of PBA originating from the BA was found to be 90.91% (40 extremities). The rate of the PBA originating from the PCHA arising from the BA was 4.55% (two extremities), and the rate of the PBA originating from the PCHA originating from the third part of the axillary artery was 4.55% (two extremities).

Very different results have been reported in the literature regarding the places of origin of the PBA. In these studies, the rate of PBA originating from the BA ranges from 55% to 100% [11-13]. The incidence of PBA originating from the axillary artery in the literature ranged from 1% to 26% [11, 12, 14]. Some case studies reported the PBA originating from the PCHA. For instance, Adachi [15] and Thelile [16] observed that the PBA emerged from the PCHA.

In a review conducted by Przybycień et al. [17] on the origin of the PBA, it was found that, on average, 94.09% of PBAs originated from the axillary or brachial arteries. The remaining 7.13% originated from the PCHA, anterior circumflex humeral artery, superior ulnar collateral, or subscapular artery. Studies on the origin of the PBA are grouped according to the continent where the study was conducted. Studies carried out in Asia found that, on average, 94.09% of PBAs originated directly from the axillary or brachial arteries. In studies conducted in North America and Europe, these rates were found to be 95.22% and 78.58%, respectively. In our study, the rate was 95.46%.

This study found that 95.46% of PBAs originated from the axillary or brachial arteries, which is very similar to the average found in studies conducted in North America. This finding indicates that our study results are consistent with the international literature and particularly align with findings in studies conducted in North America. This is the first study to examine the origin of the PBA in the Turkish population; it provides valuable contributions to the existing literature while offering new perspectives in the field of anatomy.

In this study, the incidence of double PBA was 11.36% (5/44). When studies on double PBA were examined, the percentage of double PBA in our study was higher than in these. Studies on the incidence of double PBA in the literature are summarized in Table 5 [11-13, 18-20]. However, it should be noted that our study has the smallest sample size in the literature. A study by Charles et al. [11] contains the largest sample size. It reports the lowest percentage of double PBA, suggesting an inverse relationship between sample size and the percentage of double PBA. However, this is not supported by a study conducted by Pulei et al. [12], which found a higher percentage of double PBA despite having a larger sample size than other studies [12, 16-18]. This discrepancy might be due to Pulei et al. [12]'s focus on individuals of African descent. Nevertheless, in Charles et al. [11]'s study, a nearly equal number of African-Americans (150 sides) were examined, but the percentage of double PBA was lower. To clarify the role of ethnic background in these variations, further research with more extensive and diverse populations is needed.

When the literature was examined, we found no study examining the PBA morphometrically. In this study, sex and side (right and left) comparisons were made in single PBAs (29/44: 65.91%) at the FBBA. When compared according to sex, AL, and the distance from the origin of the coracoid process, the head of the humerus and the last branch of the axillary artery to the origin of the PBA were significantly shorter in female. When compared according to side, a significant difference was found between the distance of the origin of the last branch of the axillary artery and the origin of the PBA. These differences can be attributed to anatomical structure and physiological differences between sexes. It is expected that generally shorter ALs and, therefore, shorter distances in female will be found, while differences in the distance from the origin of the last branch of the axillary artery to the origin of the PBA between the right and left sides may result from anatomical variations that can differ between individuals. These findings emphasize the importance of considering anatomical differences based on sex and side in clinical practice.

In conclusion, according to the reviewed literature, this study is the first human anatomical case study for the morphometric examination of the PBA. The morphometric measurements in the study will contribute to the literature anatomically and radiologically in the treatment of humeral

Table 5. The incidence of double profunda brachii artery in the literature

	Year	Specimens group	Number of specimens	Percentage (%)
Charles et al. [11]	1931	Adult	300	0.7
Patnaik et al. [18]	2002	Unspecified	50	2.0
Pulei et al. [12]	2012	Adult	144	11.1
Chauhan et al. [19]	2013	Adult	100	2.0
Shivanal and Gowda [20]	2017	Adult	100	2.0
Dipali et al. [13]	2020	Fetus	64	3.1
Our study	2021	Adult	44	11.3

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fractures and lateral arm-flap applications by surgeons. The current study is the first to examine PBA variations and duplications in the Turkish population. Compared to the literature, a higher rate of double PBA was observed in our study.

Additionally, this research is the first cadaver study to examine the origin of the PBA in the Turkish population. Compared to studies on the origin of the PBA, our results align with data from studies conducted in Asia and North America.

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Conceptualization: YNŞ, NZ, ÖG. Data acquisition: YNŞ, NZ, ÖG. Drafting of the manuscript: YNŞ, ÖG, AÖ. Critical revision of the manuscript: YNŞ, NZ, ÖG, AÖ. Approval of the final version of the manuscript: all authors.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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