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Original Article

Comprehensive Classification of Variations of the Anterior Part of the Circle of Willis in Fresh Cadavers Anterior Communicating Artery

Taze Kadavralarda Willis Halkasının Ön Bölümündeki Varyasyonların Kapsamlı Sınıflandırılması

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ABSTRACT

Objective: The goal of our study is to evaluate and classify the variations of the anterior communicating artery (AComA) on fresh cadavers from the Türkiye population.

Methods: In this study, 182 fresh cadavers were analysed and classified according to the number, shape and course of the AcomA.

Results: In our study, typical AcomA was the most common with a rate of 86 (47.25%), while variations of the AcomA were found in the remaining 96 (52.75%) cases. Among these variations, in 11.46% (11/96) of cases, AcomA variations were identified as distal and proximal duplications according to the number of branches they represented; 68.75% (66/96) of cases were identified by their shape (X-shaped, single/double fenestration, hypoplasia, or aplasia); and, in 19 cases, it was characterized by course (median artery or oblique course). The rate of variations was 65% (26/40) in females and 49.29% (70/142) in males. In our study, the X-shaped and single fenestration variations were recorded as the most common.

Conclusions: The results of the study are important for cerebrovascular surgery and radiological interventions. It emphasises the importance of recognising and considering variations. The study will contribute to the understanding of cerebrovascular diseases and the development of treatment strategies.

Keywords: Anterior communicating artery, variation, circle of Willis, fresh cadaver

ÖZ

Amaç: Bu çalışmanın amacı, Türk popülasyonuna ait taze kadavralar üzerinde arteria communicans anterior'un (AcomA) varyasyonlarını tanımlamak ve sınıflandırmaktır.

Yöntemler: Bu çalışmada toplamda 182 taze kadavra incelendi ve AcomA'nın sayısı, şekli ve seyrine göre sınıflandırılması gerçekleştirildi.

Bulgular: Çalışmamızda, tipik AcomA %47,25 oranıyla en sık görülürken, geri kalan 96 olguda AcomA'un varyasyonlarına rastlandı. Bu varyasyonlar arasında 11/96 olguda distal ve proksimal duplikasyon, 66/96 olguda şekline göre (X-şekilli, fenestrasyona sahip, hipoplazik veya aplazik) ve 19 olguda seyrine göre (median arter veya oblik seyir) AcomA varyasyonları tespit edildi. Varyasyon oranı kadınlarda 26/40 ve erkeklerde 70/142 idi. Çalışmamızda, X şekilli ve tek fenestrasyon gösteren varyasyonları en sık görülen varyasyonlar olarak kaydedildi.

Sonuçlar: Çalışmanın sonuçları serebrovasküler cerrahi ve radyolojik girişimler için önemlidir. Varyasyonları tanımanın ve dikkate almanın önemini vurgulamaktadır. Çalışma, serebrovasküler hastalıkların anlaşılmasına ve tedavi stratejilerinin geliştirilmesine katkıda bulunacaktır.

Anahtar kelimeler: Arteria communicans anterior, varyasyon, Willis halkası, taze kadavra

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INTRODUCTION

The cerebral arteries forming the Circle of Willis are very important in terms of collateral circulation of the brain. There are a number of vital anastomoses between the arteries forming the polygon[1]. In case of stenosis or occlusion of any of the arteries, these anastomotic connections ensure the continuity of collateral circulation. Variations such as aplasia and hypoplasia are risk factors for cerebrovascular events. Knowledge of both the normal anatomy of the arteries forming the cerebral arterial circle and the existing variations are extremely important for the radiologic and surgical interventions planned for this region[2-4].

The anterior communicating artery (AcomA), which connects the anterior cerebral arteries (ACAs) on both sides, is sometimes absent or may be double. From this artery, branches named anteromedial central arteries of varying numbers branch off and supply the optic chiasm, hypothalamus, cingulate gyrus, lamina terminalis, and preolfactory area[1,5,6].

This study was conducted to find variations in the AcomA, which stabilises cerebral blood flow when the main channels fail or are insufficient for different reasons. The AcomA shows many morphological variations. The adequacy or lack of recovery after vascular occlusion depends partly on the anatomical condition of the component vessel of the Circle of Willis[1,7-10]. Therefore, knowledge of such variations is of clinical importance.

MATERIALS and METHODS

Approval from the ethics committee of our study was completed in two stages. In the first stage, after obtaining permission from the scientific committee of the Forensic Medicine Institute (Istanbul, Türkiye), an ethics committee application was made; approval was obtained from Istanbul Medical Faculty Clinical Research Ethics Committee (date: 04/10/2024, decision no: 19).

Since our study was performed on autopsied cadavers, "informed consent" was not obtained. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. The study was conducted on the fresh cadavers received by Department of Morgue Specialization of the Forensic Medicine Institute, Ministry of Justice (Istanbul, Türkiye) for autopsy from 2022 to 2024.

Autopsy Procedure and Brain Examination

During the autopsy, the scalp was incised coronally using a scalpel and carefully pulled back. The temporalis muscle and its fascia were dissected, and any remaining fascial tissue on the bone was meticulously scraped away. The calvaria was then removed using a bone saw, followed by the careful removal of the dura mater to expose the underlying brain tissue.

The brain was gently retracted posteriorly from the frontal lobes, and the cranial nerves were severed at their osseous entry points to isolate the brainstem. A transverse incision was made at the brainstem near the level of the foramen magnum, allowing the complete extraction of the brain.

Subsequently, the arachnoid mater covering the cerebral arteries was dissected to fully expose the vessels of the cerebral arterial circle (Circle of Willis). The ACAs and AcomAs were examined *in situ* to preserve their natural anatomical relationships and photographed for documentation. High-resolution images were captured using a 20-megapixel Sony RX100 VII camera.

Exclusion criteria were determined as follows: before the autopsy procedure, during the autopsy, and after the brain tissue was removed.

Dissection Technique

In the first stage of dissection, the scalp was removed. The fascia covering the temporalis muscle and the muscle itself was peeled off. The calvaria was then incised with a saw according to autopsy procedures. After the dura mater was dissected, the brain tissue was exposed. The brain was deviated posteriorly from the frontal lobe, and the visible cranial nerves were cut at their entry points to the cranium. Finally, the brain stem was dissected transversely, and the brain tissue was removed from the cranium. The adherent layer of arachnoidea mater under the dura mater and just above the brain tissue was removed, and the cerebral arteries were exposed. The ACA and AcomA cerebral arteries were photographed inferiorly, without altering the normal anatomical position[11]. Photographs were taken with a Sony RX100 VII model (20 megapixel) camera.

Morphometric Evaluation of Anterior Communicating Artery

The outer diameter of the AcomA was measured from its midpoint. The measurement was performed perpendicular to the course of the AcomA using the "straight line" measurement tool in the Image J program. Arteries with a diameter of less than 1 mm were called hypoplastic in accordance with the literature[4], and included in our classification.

Morphological Evaluation of Anterior Communicating Artery

The AcomA was classified into 3 groups according to the number of branches, shape, and course. The AcomA cases that did not fit this classification were considered to be typical AcomA or Type 1 (Figure 1) and unilateral ACA A1 hypoplasia or Type 9.

Variations of Anterior Communicating Artery According to the Number of Branches (Figure 2)

1. Proximal duplication of AcomA or Type 8 (Figure 2A and Figure 2B): The variation is defined as a combination of an additional AcomA, with a contralateral A1 or A2 segment of the anterior cerebral artery. Proximal duplication of AcomA was defined as having the first artery measured at a distance of 1-2.5 mm away from the second artery.

2. Distal duplication of AcomA or Type 6 (Figure 2C and Figure 2D): The variation is a combination of an additional AcomA and a contralateral A1 or A2 segment of the anterior cerebral artery. Distal duplication of AcomA is considered if the first artery is >2.5 mm away from the second artery.

Variations of Anterior Communicating Artery According to the Shape (Figure 3)

3. The X-shaped or Type 2 (Figure 3A and Figure 3B): In this variation, the transverse AcomA, which joins the anterior cerebral arteries of both sides, is either absent or is so short that it forms an X-shape.

4. Double fenestration of AcomA or Type 11 (Figure 3C and Figure 3D): Double fenestration occurs when the lumen splits into two and merges after a certain distance.

5. Single fenestration of AcomA or Type 3 (Figure 3E and Figure 3F): A single fenestration is present when a lumen forms on AcomA.

6. Aplasia of AcomA or Type 7 (Figure 3G and Figure 3H): It is defined as the absence of the anterior communicating artery.

7. Hypoplasia of AcomA or Type 5 (Figure 3J and Figure 3K): The variation occurs when the diameter is less than 1 mm.

Variations of Anterior Communicating Artery According to the Course (Figure 4)

8. Median artery or Type 4 (Figure 4A and 4B): This variation describes a branch arising from the median line of the AcomA and extending between the hemispheres.

9. Oblique course of AcomA or Type 10 (Figure 4C and Figure 4D): This variation defines a branch that runs obliquely to connect the contralateral anterior cerebral arteries of both sides.

Statistical Analysis

Descriptive statistics were used to determine the general distribution of the morphometric measurements obtained in the study. The average, standard deviation, minimum, and maximum values were observed.

An analysis of variance (ANOVA) test was used to determine whether there was a significant difference between AcomA types. Kruskal-Wallis H-test was applied when the data did not conform to normal distribution and the assumption of homogeneity of variance was not met. In cases where a significant difference was found as a result of ANOVA or the Kruskal-Wallis test, post-hoc

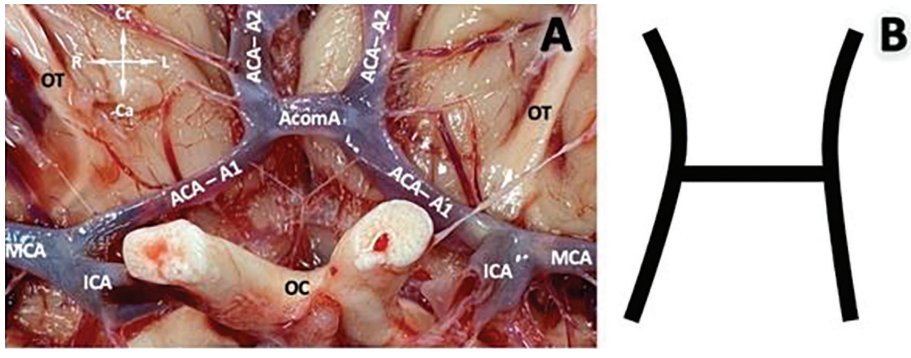

Figure 1. Demonstration of typical anterior communicating artery (AcomA). Typical AcomA of cadaver (A) and illustration (B) anterior cerebral artery (ACA)-A2: A2 segment of ACA, ACA-A1, A1 segment of ACA.

AcomA: Anterior communicating artery, ICA: Internal carotid artery, OT: Olfactory tract, OC: Optic chiasm, MCA: Middle cerebral artery, Cr: Cranial, Ca: Caudal; R: Right L: Left

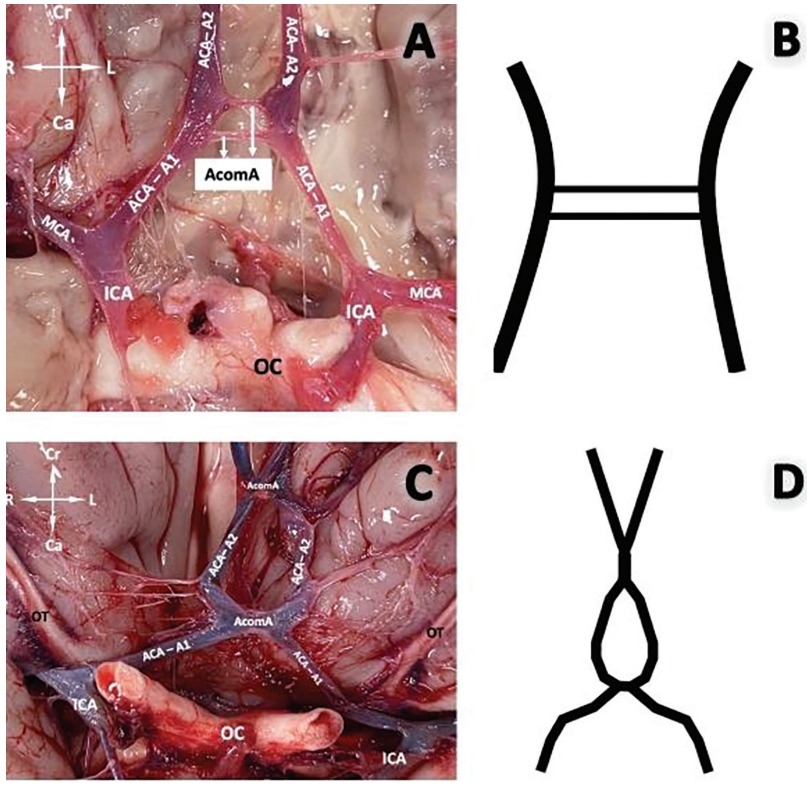

Figure 2. Various variations of the AcomA according to the number of branches. Proximal duplication of AcomA of cadaver (A), and illustration (B). Distal duplication of AcomA of cadaver (C) and illustration (D). Anterior cerebral artery (ACA)-A2, A2 segment of ACA; ACA-A1, A1 segment of ACA.

AcomA: Anterior communicating artery, ICA: Internal carotid artery, OT: Olfactory tract, OC: Optic chiasm, MCA: Middle cerebral artery, Cr: Cranial, Ca: Caudal, R: Right, L: Left

analyses were performed to determine which groups were different. The Bonferroni correction method was used in these analyses.

The Chi-square test was employed to determine whether there was a statistically significant difference between gender (female and male) and AcomA types. Fisher's exact test was applied when the expected frequency was not greater than 5 or the expected frequency was less than 1. Finally, ANOVA was used to examine whether there was a statistical difference among body mass index (BMI) and various AcomA types. The Kruskal-Wallis H-test was applied when the data were not normally distributed, and the variances of the groups were not homogeneous (checked by Levene's test). When a significant difference was found from ANOVA or the Kruskal-Wallis test post-hoc analyses (Bonferroni correction) were used to determine which groups were different. All statistical analyses were performed with Jamovi (Version 2.6), computer software (https://www.jamovi.org)[12].

RESULTS

Participant Demographics

The study included 182 cadavers, comprising 40 females (21.98%) and 142 males (78.02%).

Age: The mean age was 52.7±19.9 years for females and 48.5±17.5 years for males (Table 1).

Anthropometric Data:

Mean height: 170.19±9.59 cm

Mean weight: 77.37±19.18 kg

BMI Distribution:

Normal BMI: Mot prevalent (44.5%)

Low BMI: Least represented (4.39%)

The Classification of Acom A and the Correlations Between Gender and Body Mass Index

In 96 of 182 cadavers, 9 different variations according to the distribution of AcomA were observed. In total, 11,

Table 1. Summary of gender, age, height, weight and BMI data of the case								
					BMI			
	n	Age (mean±SD)	Height (cm) (mean±SD)	Weight (kg) (mean±SD)	Low (<18.5) n (%)	Normal (18.5-24.9) n (%)	Overweight (25-29.9) n (%)	Obese (≥30) n (%)
Male	142	48.48±17.48	173.64±5.69	78.07±17.58	7 (4.93)	66 (46.48)	39 (27.47)	30 (21.12)
Female	40	52.70±19.87	157.95±10.59	74.87±24.12	1 (2.5)	15 (37.5)	5 (12.5)	19 (47.5)
Total	182	49.40±18.05	170.19±9.59	77.37±19.18	8 (4.39)	81 (44.5)	44 (24.18)	49 (26.93)
BMI: Body mass index, SD: Standard deviation								

66 and 19 variations were described according to the number of branches, the shape and the course of AcomA, respectively. The most common variations were X-shaped, 36.36% (24/66), and single fenestration, 34.85% (23/66), variations in the group classified according to shape, among which 66 cases were identified. Hypoplastic AcomA, aplastic AcomA, and double fenestration AcomA were found in 13, 4, and 2 cases, respectively. In the classification according to the course of AcomA in 19 cases, AcomA including median artery was seen in 16/19 cases, and oblique course of AcomA was seen in only 3/19 cases. Finally, the AcomA classified according to the number of branches was detected in a total of 11 brains. Among these, distal duplication of distal AcomA was the most common with 7/11 cases, where the first AcomA was 9.78±3.59 mm (minimum: 5.48, maximum: 16.03) away from the second branch of AcomA, while proximal duplication was detected in 4/11 cases, where the first AcomA was 2.00±0.38 mm (1.43-2.24) away from the second branch of AcomA. When these variations were analyzed according to gender, X-shaped AcomAs were the most common variations in 17 of 142 male cases, and 7 of 40 female cases. The least common variation was double fenestration of the AcomA in both sexes (Table 2).

Morphological variations of the AComA were investigated, and these variations were classified according to the course of the AComA. In addition, these morphological variations were typed from Type 1 to Type 11. ANOVA and Kruskal-Wallis H-tests were performed to test whether there was a statistically significant difference among 11 types of AcomA. The p-values of ANOVA (p=0.018) and Kruskal-Wallis H (p=0.022) results indicated significant differences between the types. Therefore,

Table 2. Distribution of the courses of anterior communicating arteries according to genders.				
AcomA	**Male n (%)**	**Female n (%)**	**Total n (%)**	**P-values (ANOVA p=0.018, Kruskal-Wallis tests p=0.022)**
				Post-hoc analysis
Typical AcomA (Type 1)	**67/142 (47.18)**	**12/40 (30)**	**79/182 (43.40)**	Type 1 vs. Type 2: **p=0.045**
Unilateral ACA A1 hipoplasia **(Type 9)**	6/142 (4.22)	1/40 (2.5)	7/182 (3.84**)**	Type 1 vs. Type 3: **p=0.012**
Variations of anterior communicating artery according to the number of branches				
Distal duplication of AcomA **(Type 6)**	6/142 (4.22)	1/40 (2.5)	7/182 (3.86)	Type 1 vs. Type 4: **p=0.001**
Proximal duplication of AcomA **(Type 8)**	3/142 (2.12)	1/40 (2.5)	4/182 (2.2)	Type 2 vs. Type 3: p=0.067
Variations of anterior communicating artery according to the shape				
The X-shaped **(Type 2)**	17/142 (11.97)	7/40 (17.5)	24/182 (13.18)	Type 3 vs. Type 4: **p=0.034**
Single fenestration of AcomA **(Type 3)**	17/142 (11.97)	6/40 (15)	23/182 (12.63)	Type 5 vs. Type 6: p=0.089
Hypoplasia of AcomA **(Type 5)**	9/142 (6.33)	4/40 (10)	13/182 (7.14)	Type 6 vs. Type 7: **p=0.021**
Aplasia of AcomA **(Type 7)**	2/142 (1.42)	2/40 (5)	4/182 (2.2)	Type 7 vs. Type 8: **p=0.045**
Double fenestration of AcomA **(Type 11)**	1/142 (0.7)	1/40 (2.5)	2/182 (1.2)	Type 8 vs. Type 9: **p=0.012**
Variations of anterior communicating artery according to the course				
Median artery **(Type 4)**	13/142 (9.15)	3/40 (7.5)	16/182 (8.79)	Type 9 vs. Type 10: **p=0.034**
Oblique course of AcomA (Type 10)	2/142 (1.42)	1/40 (2.5)	3/182 (1.64)	Type 10 vs. Type 11: p=0.067
ANOVA: Analysis of variance, AcomA: Anterior communicating artery, ACA: Anterior cerebral artery				

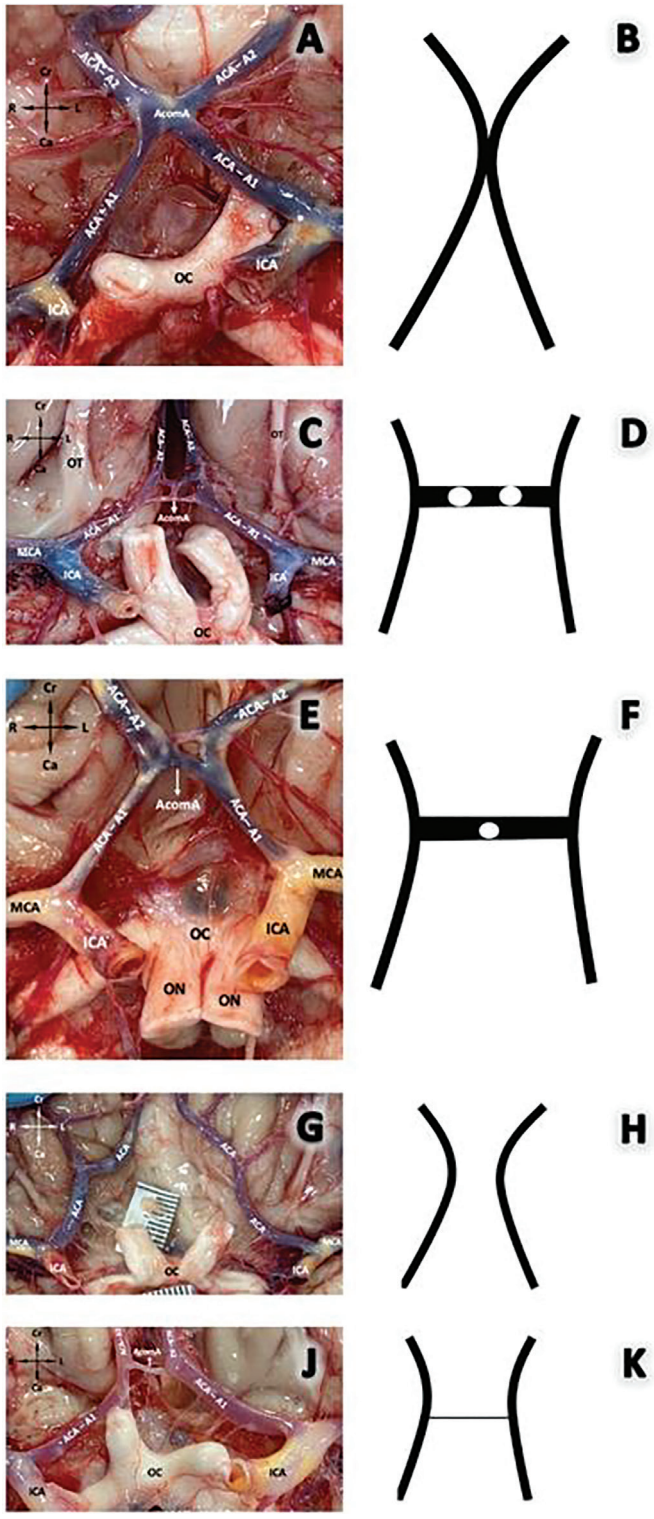

Figure 3. Various variations of the AcomA according to its shape. The X-shaped of cadaver (A) and illustration (B), Double fenestration of AcomA of cadaver (C), and illustration (D), Single fenestration of AcomA of cadaver (E) and illustration (F), Aplasia of AcomA of cadaver (G), and illustration (H), Hypoplasia of AcomA of cadaver (J), and illustration (K). ACA-A2, A2 segment of anterior cerebral artery. ACA-A1, A1 segment of anterior cerebral artery.

AcomA: Anterior communicating artery, ICA: Internal carotid artery, OT: Olfactory tract, OC: Optic chiasm, MCA: Middle cerebral artery, Cr: Cranial, Ca: Caudal, R: Right, L: Left

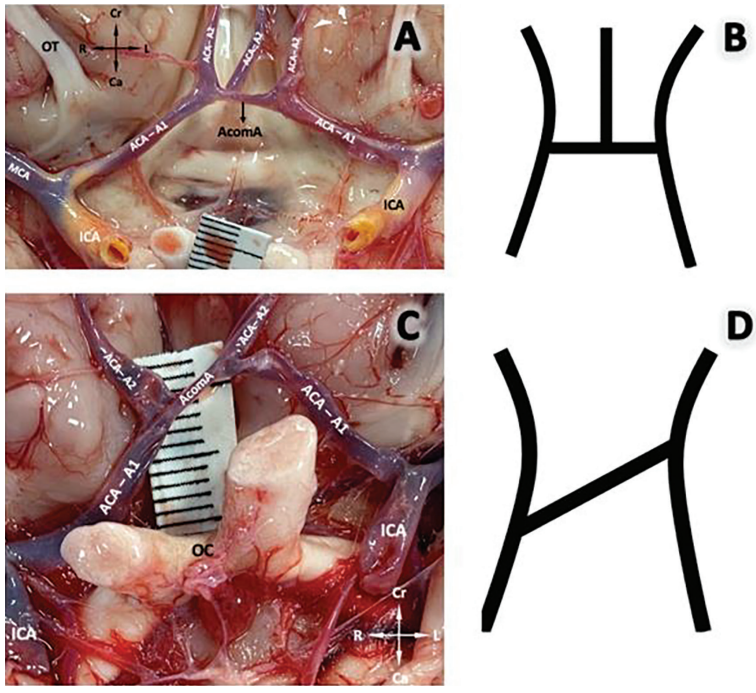

Figure 4. Various variations of the AcomA according to its course. Median artery of cadaver (A), and illustration (B), Oblique course of AcomA of cadaver (C) and illustration (D). ACA-A2, A2 segment of ACA, ACA-A1, A1 segment of ACA.

AcomA: Anterior communicating artery, ICA: Internal carotid artery, OT: Olfactory tract, OC: Optic chiasm, MCA: Middle cerebral artery, Cr: Cranial, Ca: Caudal, R: Right, L: Left

post-hoc analyses were performed to determine between which groups the significant difference occurred. The Bonferroni correction method was used in these analyses. Accordingly, significant differences were found between Types 1, 2, 3, 4, 6, 7, 8, 9, and 10 AcomA types. However, no significant difference was found in Type 2 vs. Type 3, Type 5 vs. Type 6, and Type 10 vs. Type 11 comparisons. (Table 2). After the evaluation of AcomA types between the sides, the distribution of AcomA types according to gender was also analysed. Accordingly, it was analysed whether there was a statistically significant difference between the different types of AcomA between genders. For this purpose, the χ^2 test was used (p=0.045). When the assumptions of the Chi-square test were not fulfilled, Fisher's exact test was applied (p=0.038). Although the results of both tests were similar, there was a statistically significant correlation between sex and AcomA types. It was determined that AcomA types such as Type 1, Type 3, and Type 4 were observed at different frequencies between males and females (Table 3). For example, Type 1 was the most common type of AcomA in both males and females. However, it was more common in males. Rarer AcomA types, such as Type 10 and Type 9, were found to have similar frequencies in both genders (Table 3).

In our study, most of the sample consisted of cadavers with normal BMI (81/182), (Table 4). Of the sample group, 49 were obese, 44 were overweight, and 8 had a low BMI. In the normal BMI group, Type 1 was observed in 54.32% of cases (44 out of 81). There were 8 cases of both Type 2 and Type 4 AcomA variations among cadavers with normal BMI, constituting 9.88% (8/81) in each group, respectively. However, the variations with Type 8 and Type 9 were the least common, 1.23% (1/81). In the obese BMI group, Type 1 was observed in 32.65% of (16-49) cases. Similarly, the most common variations were Type 2 14.28% (7/49) and Type 3 14.28% (7/49), while the least common were Type 6 2.04% (1/49) and Type 10 2.04% (1/49). No cadavers with Type II (0/49) were found. In cases of overweight BMI, Type 1 was determined in 43.18% (19/44) cadavers. Additionally, Type 3 was the most commonly seen, 6.82% (3/44), AcomA variation in this group, and Type 8, 2.27% (1/44), and Type 10, 2.27% (1/44), were the least common types seen. Type 7 (0/44), Type 9 (0/44), and Type 11 (0/44) were not encountered in this category of BMI. Finally, the cases with low BMI were analyzed according to the various types of AcomA. In four of eight cadavers, the AcomA was observed as Type 2. Also, Type 5 (2/8) and

Table 3. Distribution of the types of anterior communicating arteries according to subtypes of BMI.					
Types of AcomA	**BMI**				**Total**
	Low (<18.5)	**Normal (18.5-24.9)**	**Overweight (25-29.9)**	**Obese (>30)**	
Type 1	0	44	19	16	**79**
Type 2	4	8	5	7	**24**
Type 3	0	6	10	7	**23**
Type 4	0	8	3	5	**16**
Type 5	2	3	2	6	**13**
Type 6	0	3	3	1	**7**
Type 7	2	3	0	2	**7**
Type 8	0	1	1	2	**4**
Type 9	0	2	0	2	**4**
Type 10	0	1	1	1	**3**
Type 11	0	2	0	0	**2**
Total	**8**	**81**	**44**	**49**	**182**

BMI: Body mass index

Table 4. Statistical analysis between gender and AcomA type.				
Gender	**Type**	**Age (mean+SD)**	**BMI (mean+SD)**	**p-values (Chi-squared test/ Fisher's exact test)**
Female	Type 1 (n=12)	45.3+12.5	23.8+2.9	Chi-squared test: p=0.045* Fisher's exact test: p=0.038**
	Type 2 (n=8)	50.1+15.2	24.5+3.1	
	Type 3 (n=6)	48.7+14.8	25.2+3.4	
	Type 4 (n=5)	52.3+16.1	26.1+3.8	
	Type 5 (n=4)	47.5+13.9	22.9+2.7	
	Type 6 (n=3)	49.0+14.5	21.6+2.8	
	Type 7 (n=2)	55.0+17.3	27.5+4.1	
	Type 8 (n=1)	58.0	26.8	
	Type 9 (n=2)	60.5+18.2	28.1+4.3	
	Type 10 (n=1)	62.0	29.0	
	Type 11 (n=1)	50.0	24.5	
Male	Type 1 (n=33)	44.2+11.8	24.8+3.0	
	Type 2 (n=12)	46.5+13.4	23.7+2.8	
	Type 3 (n=12)	47.8+14.1	25.0+3.3	
	Type 4 (n=10)	49.5+15.0	26.5+3.9	
	Type5 (n=6)	45.0+12.7	22.7+2.6	
	Type 6 (n=5)	47.0+13.8	21.3+2.7	
	Type 7 (n=5)	53.0+16.5	26.9+3.7	
	Type 8 (n=4)	56.0+17.0	27.0+3.8	
	Type 9 (n=4)	58.0+18.0	28.5+4.2	
	Type 10 (n=3)	60.0+18.5	29.2+4.0	
	Type 11 (n=2)	48.0+12.0	24.6+2.9	

*Chi-square test: A statistically significant difference was found between genders and artery types (p<0.05). **Fisher's exact test: This test was used because the assumptions of the chi-square test were not met. The results are similar.

BMI: Body mass index, SD: Standard deviation

Table 5. Statistical analysis between BMI findings and AcomA types.			
Type	**BMI (mean+SD)**	**P-value (ANOVA/Kruskal-Wallis)**	**Post-hoc analysis**
Type 6	21.45+2.89	0.023	Type 1 vs. Type 2: **p=0.045**
Type 5	22.78+2.56		Type 1 vs. Type 3: **p=0.012**
Type 2	23.89+2.98		Type 2 vs. Type 3: p=0.067
Type 11	24.56+2.78		Type 1 vs. Type 4: **p=0.001**
Type 1	24.56+3.12		Type 3 vs. Type 4: **p=0.034**
Type 3	25.12+3.45		Type 5 vs. Type 6: p=0.089
Type 4	26.34+4.01		Type 6 vs. Type 7: **p=0.021**
Type 8	26.89+3.45		Type 7 vs. Type 8: **p=0.045**
Type 7	27.12+3.78		Type 8 vs. Type 9: **p=0.012**
Type 9	28.34+4.12		Type 9 vs. Type 10: **p=0.034**
Type 10	29.12+3.89		Type 10 vs. Type 11: p=0.067
BMI: Body mass index, SD: Standard deviation, ANOVA: Analysis of variance			

Type 7 (2/8), cases were associated with low BMI. Cases of other AcomA types were not observed (Table 4).

BMI values of cadavers with various AcomA types (Type 1, Type 2, Type 3, ..., Type 11) were compared using ANOVA and Kruskal-Wallis tests. The p-value (0.023) obtained as a result of ANOVA/Kruskal-Wallis tests showed that there was a statistically significant difference among AcomA types corresponding to different BMI categories ($p<0.05$). This mean that cadavers with different AcomA types might have different BMI values. Post-hoc analyses were used to determine which group was significantly different, and it was found that there were significant differences among Type 1 and Type 2, Type 3 vs. Type 4, Type 3 and Type 4, Type 7 and Type 6, Type 7 and Type 8, Type 9 and Type 8, Type 9 and Type 10 AcomA types in terms of BMI values. BMI averages of cadavers with Type 9 and Type 10 AcomA types were higher than those of the other groups. BMI averages of cadavers with Type 5 and Type 6, AcomA types were found to be lower than the other groups (Table 5).

DISCUSSION

In our study, the variations of AcomA were observed in 96/182 fresh cadavers. The remaining 86 cases were included in the category of typical AcomA. these variations (96/182) have been classified in various ways, including the number, course, or shape of AcomA[7]. Each of these had a subtype, and the most common AcomA variation among all the main classifications were those classified according to shape. In the literature, AcomA has been reported to vary between 6.27% and 59.38%[13,14]. This rate was found to be 52.75% in our study on fresh cadavers. To date, studies related to the variations of AcomA have been performed on fresh cadavers, fixed cadavers, magnetic resonance imaging angiography and computed tomography angiography (CTA)[14-18].

In the 182 recently deceased cadavers analyzed in the study, 96 variations related to the AcomA were detected. The most common variation was the X-shaped AcomA (24/96), and the AcomA with single fenestration (23/96), while the rarest variation was AcomA with double fenestration (2/96). The prevalence of fenestration variations reported in the literature is between 0.9% and 2%[2,7,19]. Fenestration-related variations, which were relatively high in our study, play an essential role in aneurysms. The fact this ratio was higher in our study than in the literature may be due to the characteristics of sample used in the study or the effects of post-mortem processes that may cause fenestration structures to become more prominent. In general, fenestrations in arteries are associated with a significant increase in the risk of rupture. They are also linked to aneurysm formation due to developmental problems such as weakness in the tunica layers of the arterial wall[20,21]. When the demographic data of the cadaver samples were analysed, the effect of factors such as gender on the variation types was observed. Kardile et al.[7] reported that AcomA showed variation in 18/48 (37.5%) females and 20/52 (38.46%) males. In our study, variations of AcomA were found in 26/40 females and 70/142 males. This high rate in female cases is thought to be due to factors such as lower reporting or diagnosis rates compared to male cases[7].

The anterior cerebral arteries and the anterior communicating artery are critical components of the Willis polygon and play an important role in maintaining the continuity of cerebral blood circulation. Morphological variations of AcomA may be especially effective in the pathophysiology of cerebrovascular diseases. In our study, structural variations such as hypoplasia, aplasia, and fenestration

were determined. It has been reported in the literature that such variations may affect the incidence of cerebrovascular events and may cause technical difficulties in surgical interventions[1,5,22]. Particularly hypoplastic and aplastic variations may increase the risk of complications during surgical interventions by decreasing the adequacy of collateral circulation[23]. Therefore, detection of these variations in preoperative angiographic evaluations is of great importance for the success of surgical planning.

Advanced imaging modalities, such as 3D reconstruction or maximum intensity projection images, may be useful for the identification of AcomA. Among the possible variants of AcomA, absence, double, fenestrated, and triple AcomA have been reported in the literature. Other rare cases include AcomA X, Y, V, H, or N[19]. There is some controversy in the literature about the frequency of anatomical variants of AcomA. Some authors describe the absence of the AcomA as the most common atypical vascular variant with a prevalence of approximately 14%[24] and 19%[15], while other authors claim that definite absence of the anterior communicating artery is found in 5% of surgical dissections[21]. This disagreement may arise from the fact that among the limitations of some studies was the inability of CTA source images to visualize very small arteries, possibly leading to the misdiagnosis of some hypoplastic arteries as aplastic arteries[15]. For this reason, the findings of studies that are illustrated by the use of dissection become more important.

Study Limitations

Limitations of this study include that the sample group was taken from only from one region and that only fresh cadavers were examined. In future research, similar studies on larger and more diverse populations will increase the generalisability of the findings. Furthermore, increasing the sample size would enable a more robust and statistically significant evaluation of correlation results stratified by BMI or sex. Given the considerable variability in AcomA types and despite the relatively large sample size used in this study, the interpretation of correlation findings between these types remains limited. Distribution of results by subtypes may not yield ethically applicable and generalizable results due to the inherent heterogeneity observed.In addition, prospective studies evaluating the clinical outcomes of these variations will provide more data for surgical and radiological applications.

CONCLUSION

This study has examined and classified the morphological variations of the AcomA on fresh cadavers in a sample from Türkiye. The findings provide important clinical information, especially for cerebrovascular surgery and radiological interventions. Variations such as hypoplasia, aplasia and fenestration identified in the study may affect the haemodynamics of cerebral vessels, alter the adequacy of collateral circulation and predispose to aneurysm formation. Therefore, the detection of these variations in preoperative imaging processes may help to plan surgical and endovascular interventions more safely and effectively. It should be kept in mind that hypoplastic and aplastic variations, especially, may lead to adverse complications due to insufficient blood flow during surgery.

This study contributes to the literature by being performed on fresh cadavers. The data obtained by dissection reveal the anatomical details of the vascular structures more accurately compared to previous studies performed with imaging methods. Moreover, the higher rate of fenestration-related variations in this study compared to the rates reported in the literature, suggests that more research should be conducted on the clinical effects of these variations. These anatomical differences should be taken into consideration in the diagnosis and treatment of cerebrovascular diseases.

Ethics

Ethics Committee Approval: Approval was obtained for this study from the Istanbul Medical Faculty Clinical Research Ethics Committee (date: 04/10/2024, decision no: 19).

Informed Consent: Since our study was performed on autopsied cadavers, "informed consent" was not obtained.

Footnotes

Author Contributions

Surgical and Medical Practices: G.N.C., E.N., Concept: G.N.C., Design: G.N.C., E.N., Data Collection or Processing: G.N.C., K.A., Analysis or Interpretation: G.N.C., E.N., Literature Search: G.N.C., O.C., Writing: G.N.C., A.K., Ö.G.

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