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Research Article

Variations of the anterior part of circle of Willis in human cadavers: a dissection study

Vaibhav V. Sande[1]*, Sanjay P. Wanjari[1], Suvarna V. Sande[2]

[1]Department of Anatomy, [2]Department of Microbiology, Jawaharlal Nehru Medical College, Wardha, Maharashtra, India

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***Correspondence:**
Dr. Vaibhav V. Sande,
E-mail: vaibhavsande690@hotmail.com

ABSTRACT

Background: Vascular anatomy of anterior cerebral artery (ACA), anterior communicating artery (ACoA) and its branches is quite complex and known for its variations. Most of the variations have been reported on posterior cerebral and posterior communicating arteries. However, there are very few case reports regarding variations encountered in the ACA and ACoA. Hence, the present study was undertaken to study the origin, course and termination of ACA, to observe the ACoA, and to observe variations associated with them.
Methods: 30 human brain specimens were removed from embalmed cadavers. Vernier calliper was used to measure the length and external diameter of ACA and ACoA. Variations were observed with reference to presence or absence, size, shape and mode of anastomosis.
Results: Out of 30 cases; in anterior part, the circle of Willis was incomplete in 1 case and anomalous in 5 cases. Pre-communicating ACA (A1 segment) was absent in 2 cases and hypoplastic in 1 case. Azygous ACA was seen in 3 cases. ACoA was absent in 4 cases. Out of the 26 cases of ACoA, 'H' shaped ACoA – ACA complex was most commonly found.
Conclusions: Variations of the anterior part of circle of Willis are not quite rare as believed.

Keywords: Circle of Willis, Variations, Anterior part

INTRODUCTION

The cerebral hemispheres and the walls of the diencephalon are supplied by both the carotid and the vertebral systems which anastomose remarkably to form 'the circulus arteriosus'. It is formed by the internal carotid artery which is interconnected via the anterior cerebral arteries on both the sides (right and left) and an anterior communicating artery which connects the right and the left anterior cerebral arteries. The carotid system is connected to the posterior cerebral arteries of the vertebral system by two posterior communicating arteries (right and left).[1-3] This arterial circle is more commonly called 'the circle of Willis', named after Thomas Willis (1621 – 1673) who was an English physician.[4] The circle of Willis has an important role in maintaining a stable and constant blood flow to the cerebral hemisphere.[5] Most of the anatomical variations have been reported on the posterior cerebral and posterior communicating arteries. However there are very few case reports regarding the variations encountered in the ACA and ACoA.[6-8] Hence, the present study was undertaken to study the origin, course and termination of the ACA, to observe the ACoA and to observe variations between the two sides.

METHODS

30 human brain specimens irrespective of any particular age group were removed from embalmed cadavers. The

brains were removed en-mass by adopting the dissection procedures as given in the Cunningham's 'manual of practical anatomy' volume III: head and neck and brain, 15th edition. The meninges were removed carefully from the interpeduncular fossa and the circle of Willis along with the major arteries was dissected and observed in situ. The specimens were preserved in 5% formalin.

The detailed study of the anterior part of the circle of Willis was made and findings were noted and tabulated with reference to position and course of ACA and ACoA, its completeness and any anomalies encountered. Vernier calliper (Mitutoyo model), graduated to measure up to 0.1 mm, was used to measure the length and the external diameter of the ACA and ACoA.

The measurement of the external diameter of the ACoA was taken at the midpoint and that of the right and left ACA (A1 segment) close to their origin. A1 segment is the part of the ACA before the communication with ACoA. The ACAs measuring less than 1 mm in diameter were considered to be abnormal barring the ACoAs, where less than 0.5 mm diameter was considered to be abnormal. The measurement of the lengths of the right and left A1 segment was taken from the point of its origin to the point of the ACoA communication while that of the ACoA was taken from the point of communication between right A1 segments to the left A1 segment.[9]

RESULTS

In the present study, the circle of Willis was incomplete in 1 of the 30 (3.33%) cases in the anterior part. Out of the 30 cases, in anterior part, the circle was anomalous in 5 (16.66%) cases. The average length of right and left A1 segment was 14.4±0.53 mm and 14.5±0.16 mm respectively and that of ACoA was 4.4±0.23 mm. The average external diameter of right and left A1 segment was 1.96±0.09 mm and 2.06±0.08 mm respectively while that of ACoA was 2.00±0.16 mm.

A1 segment

The A1 segment was present in 28 (93.33%) cases and absent in 2 (6.66%) cases, one on right side and one on the left side. The artery was found to be hypoplastic in 1 case on the right side (3.33%). Azygous ACA was seen in 3 (10%) cases.

ACoA segment

ACoA was absent in 4 of the 30 (13.33%) cases. Out of these 4 cases, a complete absence was seen in only 1 (3.33%) case, azygous ACA was seen in 3 (10%) cases. The artery was present in 26 (86.66%) of the 30 cases.

ACoA-ACA complex

Out of the 26 cases of ACoA, the 'H' shaped ACoA-ACA complex was most commonly found in 21 (70%) cases and 'V' complex in 3 (10%) cases. The artery was fenestrated and double in 1 case each which accounted to 3.33%.

DISCUSSION

Detailed knowledge of the vascular anatomy of ACoA complex and recognition of the anomalies has a significant importance during neurointerventional procedures. Many descriptions of the anomalies and variations in the vascular anatomy of the ACA (fenestration, duplication and azygous) and ACoA (fenestration, duplication and triplication) are intimated in the literature.[10]

The incidence of anomalous anterior part of circle of Willis has been reported to be as low as 29.16% to as high as 68%.[11,12] Our study revealed about 16.66% of anterior part anomalies.

In 4 previous studies, the absence of the A1 segment of ACA was found to be 0.4%, 1%, 1-2% and 0.7-11% cases.[13-16] In the present study, the A1 segment was absent in 6.66% cases 1 on each side (right and left side respectively). The mean length of the A1 segment on the right side was 14.7±0.3 mm and on the left side was 18±0.27 mm. The mean external diameter of ACA on the right side was 2±0.6 mm and on the left side 2.4±0.5 mm.[9] Orlandini et al give the mean length of ACA on the right side to be 14.1±2.7 mm and on the left as 13.6±2.8 mm.[17] Stephen and John give the average range of external diameter of A1 segment to be 0.2±3.4 mm.[18] As shown in Table 1, our findings on average length and external diameter of A1 segment very closely correspond to these studies.

Table 1: Average length and external diameter of A1 segment and ACoA.

Name of the arterial segment	Length (mm)		Diameter (mm)	
	Right	Left	Right	Left
A1 segment	14.4± 0.53	14.5± 0.16	1.96± 0.09	2.06± 0.08
ACoA	4.4±0.23		2.00±0.16	

A1 segment – part of anterior cerebral artery before communicating with anterior communicating artery; ACoA – anterior communicating artery.

The average length of ACoA was reported to be 2-3 mm that may vary from 0.3 mm to 7 mm in length.[19] According to Luzsa's study, the average length of ACoA ranges between 0.75-2.75 mm.[16] Kamath S reported 2.5±1.8 mm as the average length of ACoA and 1.9±9 mm as the average external diameter.[9] Orlandini et al documents the mean value for ACoA to be 2.8±1.8 mm.[17] Vohra et al reported from their comparative study, that the average calibre of the ACoA in gross specimens was

0.5-1.5 mm and magnetic resonance angiographic study showed that the average calibre was 0.5-1.75 mm.[20] These studies provide supporting evidence for the present findings, which show the average length of the artery as 4.4±0.23 mm and the average external diameter of the artery as 2±0.16 mm (Table 1).

In the present study, as shown in Table 2 and Table 3, hypoplasia of A1 segment was present in 3.33% cases on the right side with contra lateral hyperplasia to compensate the vascular insufficiency. We encountered azygous ACA in 10% cases. Some authors reported hypoplasia of the A1 segment to be 2% and 9.61%.[16,18,21] The incidence of azygous ACA is reported in the literature in the ranges from 0.2 - 4%[22, 15] which is lower than our findings.

Complete absence of ACoA, fenestrated and double ACoA accounted for 3.33% each in our study (Table 3). Windle and Bertram reported absent ACoA in 3% and double ACoA in 3% of the cases.[14] In their study on 70 human brain specimens, Swetha B et al observed fenestration of ACA in 2.8% cases.[10]

Table 2: A1 segment findings.

A1 segment	Present	Absent – 2 (6.66%)			Hypoplasia		
		Both	A1 –right	A1 – left	Both	A1 – right	A1 - left
No. of cases	28	-	1	1	-	1	-
Percentage	93.33%	-	3.33%	3.33%	-	3.33%	-

Table 3: Variations of ACoA-ACA complex.

ACoA-ACA complex	Absent ACoA- 4 (13.33%)		Present- 26 (86.66%)			
	Complete absence	Azygous ACA	H complex	V complex	Fenestrated	Double
No. of cases	1	3	21	3	1	1
Percentage	3.33%	10%	70%	10%	3.33%	3.33%

ACA – anterior cerebral artery.

CONCLUSION

The conclusion of the present study was, 9 anatomical variations of the anterior part of circle of Willis out of 30 specimens (30%) have been observed which is quite significant. The precise knowledge of these variations are concerned with complete absence, fenestration, duplication of ACoA, absent A1 segment and azygous ACA which are very important and should be recognized pre-operatively to minimize surgical complications.

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