

Quantitative study of anterior cerebral artery

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Abstract

In the present study statistical analysis of Anterior cerebral artery was done to set normal reference value for calculable parameters and find out whether there was any significant difference in age, sex in relation with side in 100 apparently normal formalin fixed brains of human cadavers. There was highly significant statistical difference in the mean length of right and left anterior cerebral artery. From this study it was observed that the anterior cerebral artery in a majority of cases had greater length on the right side. There was highly significant statistical difference in the mean diameter of right and left anterior cerebral artery. The knowledge of the normal length and diameter of these vessels is useful to the surgeons in assessing the practicability of shunt operations and choose patient for procedures appropriately.

Key Words: Anterior cerebral artery, azygous artery, Length, Diameter.

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INTRODUCTION

Formation of vascular anastomosis in the interpeduncular fossa at the base of brain was described by Thomas Willis in 1664. Thereafter many authors reported normal and abnormal pattern of the circle. As literatures on quantitative assessment of component vessels of the circle of Willis are rare, present study was conducted for statistical analysis of Anterior cerebral artery to set normal reference value for calculable parameters and find out whether there was any significant difference in age, sex in relation with side. The knowledge of the normal length and diameter of these vessels is useful to the surgeons in assessing the feasibility of shunt operations and in the choice of patients.¹

MATERIAL AND METHOD

With prior approval from ethical committee of the institution one hundred apparently normal brain specimens of human cadavers with known age and sex were collected from various government medical colleges for three consecutive years. The intact brains removed from the cranial cavity were fixed in 10% formalin. The formation of Circle of Willis was observed around optic chiasma and interpeduncular fossa. Part of base of the brain was cut and removed in piece-meal if it was necessary to expose the arterial circle clearly.² The arterial circle was then photographed, numbered and the detail identity of the cadavers was noted. A Vernier calliper graduated to measure up to 0.1 mm was used to measure the length and diameter of component vessels. The external diameter of the Anterior cerebral artery was taken at three points, at its two ends and at the midpoint and then its average diameter was obtained. Each measurements were taken twice. Any vessel with a diameter less than 1 mm has been described as hypoplastic by various authors.^{3,4,5} This definition was accepted in present study. Average length and diameter for each of component vessel was measured for both sexes and standard deviation and coefficient of variation was calculated. The sample was divided into three categories according to their age i.e. 26 to 50 years, 51 to 75 years and more than 76 years. Statistical analysis was

done by applying ANOVA test to find out whether there was any significant difference in age, sex in relation with side. Absent and immeasurable vessels were excluded from statistical study.

OBSERVATION

Table 1: Mean length and diameter of anterior cerebral arteries

Parameter	Side	No of observations	Mean (mm)	Standard Deviation	z value	p value
Length	Right	85	14.684	1.132	3.489	0.000
	Left	96	13.986	1.506		
Diameter	Right	85	2.274	0.424	2.741	0.007
	Left	96	2.458	0.494		

In the present study, 100 formalin fixed specimens of brain were studied from human cadavers, of which 58 were males and 42 were females. The quantitative study included measurement of length and diameter and statistical analysis of Anterior cerebral artery. Observations were divided into two groups, Group A and

Group B. Group A included subjects having only normal individual vessels under consideration while Group B included both normal and measurable variant vessels under consideration. Absent and immeasurable vessels were excluded from statistical observation in both the groups. On studying 100 Circle of Willis, two anterior cerebral arteries were absent on the right side and 13 arteries showed variations on the same side. On the left side 4 anterior cerebral arteries showed variations. So the variations were more common on the right side than on the left side. In the table no 1, the mean length and diameter of the anterior cerebral artery were recorded in millimetres. There was highly significant difference in mean length of right and left anterior cerebral artery. In Group A, there was highly significant difference in mean diameter of normal anterior cerebral artery. When we combine the normal and variant vessels (Group B), there was highly significant difference in mean length and mean diameter of right and left anterior cerebral arteries.

Table 2: Greatest and smallest measured values and coefficient of variation (COV) for anterior cerebral arteries

Type of vessels	Side	LENGTH			DIAMETER		
		Greatest (mm)	Smallest (mm)	COV (%)	Greatest (mm)	Smallest (mm)	COV (%)
Group A	Right	19	6	7.702	3.5	1.4	18.73
	Left	16	6	10.765	5	1.5	20.09
Group B	Right	19	6	9.654	4.6	0.6	23.71
	Left	17.5	6	10.846	5	1.5	19.698

As per above table no 2, in the Group A, coefficient of variation was more for the diameter than for the length. It was greatest for the diameter of left anterior cerebral artery while it was minimum for the length of right anterior cerebral arteries. The coefficient of variation was

more for the left side than for the right side. In Group B, coefficient of variation was more for the diameter than for the length. The coefficient of variation was greatest for the diameter of right anterior cerebral artery while it was minimum for the length of right anterior cerebral artery.

Table 3: The mean length and standard deviation of anterior cerebral artery according to age

Group	Side	Age Groups (Years)	No of vessels	Mean (mm)	Standard Deviation	ANOVA	
						f - value	p - value
Group A	Right	26 to 50	23	14.913	0.964	2.086	>0.05
		51 to 75	42	14.764	0.412		
		≥ 76	20	14.255	1.98		
	Left	26 to 50	26	14.173	1.132	1.349	>0.05
		51 to 75	47	14.1	1.235		
		≥ 76	23	13.543	2.210		
	Both	26 to 50	49	14.52	1.110	3.045	0.050
		51 to 75	89	14.413	0.993		
		≥ 76	43	13.874	2.115		
Group B	Right	26 to 50	25	14.848	1.002	0.836	>0.05
		51 to 75	50	14.67	1.09		
		≥ 76	23	14.33	2.217		
	Left	26 to 50	27	14.203	1.121	1.624	>0.05
		51 to 75	50	14.184	1.295		
		≥ 76	23	13.543	2.210		
	Both	26 to 50	52	14.513	1.104	2.284	>0.05
		51 to 75	100	14.427	1.215		
		≥ 76	46	13.93	2.224		

In table no. 3, for Group A, the length went on decreasing with increasing age. There was no significant difference in the mean length of right and left anterior cerebral artery according to age. For Group B, the length

decreased with increasing age. There was no significant difference in the mean length of right and left anterior cerebral artery according to age.

Table 4: The mean diameter and standard deviation of anterior cerebral artery according to age

Group	Side	Age Groups (Years)	No of vessels	Mean (mm)	Standard Deviation	ANOVA	
						f - value	p - value
Group A	Right	26 to 50	23	2.173	0.338	1.813	>0.05
		51 to 75	42	2.359	0.440		
		≥ 76	20	2.21	0.461		
	Left	26 to 50	26	2.338	0.285	1.036	>0.05
		51 to 75	47	2.512	0.484		
		≥ 76	23	2.482	0.667		
	Both	26 to 50	49	2.261	0.319	2.386	>0.05
		51 to 75	89	2.440	0.468		
		≥ 76	43	2.355	0.590		
Group B	Right	26 to 50	25	2.116	0.438	2.863	>0.05
		51 to 75	50	2.404	0.592		
		≥ 76	23	2.182	0.462		
	Left	26 to 50	27	2.340	0.280	1.113	>0.05
		51 to 75	50	2.508	0.470		
		≥ 76	23	2.482	0.667		
	Both	26 to 50	52	2.232	0.378	3.649	<0.05
		51 to 75	100	2.456	0.534		
		≥ 76	46	2.332	0.588		

Table no 4, shows that when both right and left were combined and analysed for mean diameter there was significant difference. There is no significant difference in mean length of right and left anterior cerebral artery according to sex.

Table 5: The mean diameter and standard deviation of anterior cerebral artery according to sex

Group	Side	Sex	No of vessels	Mean (mm)	Standard Deviation	z - value	p - value
Group A	Right	Male	50	2.474	0.331	-	<0.0001
		Female	35	1.988	0.380	6.045	
	Left	Male	58	2.555	0.336	-	<0.05
		Female	38	2.310	0.644	2.212	
	Both	Male	108	2.517	0.334	-	<0.0001
		Female	73	2.156	0.555	4.943	
Group B	Right	Male	57	2.443	0.128	-	0.002
		Female	41	2.048	0.822	3.095	
	Left	Male	58	2.555	0.336	-	<0.05
		Female	42	2.321	0.613	2.303	
	Both	Male	115	2.5	0.317	-	<0.0001
		Female	81	2.186	0.669	3.906	

As per table no.5, on statistical analysis there was significant difference in the mean diameter of right and left anterior cerebral artery according to sex. In Group A, males had mean diameter more than the females on both right and left side. The mean diameter was maximum for the left side of anterior cerebral artery of males while it was minimum on the right side in the females. In Group B, the males had mean diameter more than the females on both right and left side. The mean diameter was maximum for the left side of anterior cerebral artery in males while it was minimum on the right side in the females. There was significant difference in the mean diameter of right and left anterior cerebral artery according to sex.

DICUSSION

Table 6: Comparison of mean length and diameter of Anterior cerebral artery

Authors	Length (mm)				Diameter (mm)			
	Right		Left		Right		Left	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Sylvia Kamath	14.7	3.0	13.8	2.7	2.2	0.6	2.4	0.5
Present study Group A	14.684	1.132	13.986	1.506	2.274	0.424	2.458	0.494
Present study Group B	14.635	1.413	14.042	1.523	2.278	0.539	2.457	0.484

Various parameters taken in the present study is essential to know changes in the dimensions cause shifting in the configuration of the circle. The haemodynamics of the

circle is influenced by variations in the calibre of individual vessel of the circle.¹ In the present study, as shown in table no 6, the mean length of anterior cerebral

artery (Group A and Group B) on the right side was more than the left side. The mean diameter of anterior cerebral artery (Group A and Group B) was more on the left side than on the right side. Similar findings were noted by Sylvia Kamath⁶. In the study by Parthapratim Pradhan⁷, length of each vessel was not mentioned separately. Orlandini⁸ reported observations similar to our study. The diameter of component vessels of the Circle of Willis was

greater on the left side. According to Sylvia Kamath⁶, the volume of blood flow through a vessel is inversely related to the length of vessel and directly related to its diameter. Therefore, blood flow through shorter and wider vessel was more efficient. From this study it was apparent that the component vessels of circle have in majority of cases a greater length and a smaller diameter in the right half of the circle.

Table 7: Comparison of Greatest, Smallest and coefficient of variation (COV) of Anterior cerebral artery

Type of vessels	Side	LENGTH			DIAMETER		
		Greatest (mm)	Smallest (mm)	COV (%)	Greatest (mm)	Smallest (mm)	COV (%)
Group A	Right	19	6	7.702	3.5	1.4	18.73
	Left	16	6	10.765	5	1.5	20.09
Group B	Right	19	6	9.654	4.6	0.6	23.71
	Left	17.5	6	10.846	5	1.5	19.698
Sylvia Kamath	Right	25.6	3.4	20.26	3.9	0.6	26.82
	Left	21	3.1	19.84	3.6	1.1	22.14

As per table no 7, in the present study, the coefficient of variation of the length was less for the right anterior cerebral artery while it was more for the left anterior cerebral artery. In the study by Sylvia Kamath⁶, the coefficient of variation of the length was more for the right anterior cerebral artery while it was less for the left anterior cerebral artery. Similar to our findings, Sylvia Kamath⁶ also noted that the coefficient of variation of the diameter was higher for the right anterior cerebral artery than the left anterior cerebral artery.

Table 9: Comparison of mean diameters anterior cerebral artery according to the age

Authors	Side	Age Group (year)	Standard deviation	p value
Krabbe Hartkamp	Right	20-25	2.3	<0.001
		> 60	1.8	
	Left	20-25	2.2	<0.001
		> 60	1.7	
	Both	20-25	2.2	<0.001
		> 60	1.8	
Present study Group A	Right	26 to 50	2.173	>0.05
		51 to 75	2.359	
	Left	≥ 76	2.21	>0.05
		26 to 50	2.338	
	Both	51 to 75	2.512	>0.05
		≥ 76	2.482	
Present study Group B	Right	26 to 50	2.261	>0.05
		51 to 75	2.440	
	Left	≥ 76	2.355	>0.05
		26 to 50	2.116	
	Both	51 to 75	2.404	>0.05
		≥ 76	2.182	
Present study Group B	Right	26 to 50	2.340	>0.05
		51 to 75	2.508	
	Left	≥ 76	2.482	>0.05
		26 to 50	2.232	
	Both	51 to 75	2.456	<0.05
		≥ 76	2.332	

In the present study, on statistical analysis there was no significant difference in the mean diameter of right and left anterior cerebral artery according to age. Krabbe-Hartkamp *et al*⁹ used phase contrast Magnetic Resonance Angiography. In his study the mean diameter of the vessel was significantly larger in older individuals. Limitation of his study was low intensity vessels were lost on maximum intensity projection images. Sylvia Kamath⁶ in her study mentioned the significant difference in the sides (right/left) of the vessel but did not mention its age. Parthapratim *et al*⁷ mentioned only the mean length of vessels. However the caliber of each vessel was not measured. K.R.D. De Silva *et al*¹⁰ in their study measured the diameter of component vessels of the circle and divided it into two groups namely hypoplastic vessels having diameter less than 1 mm and other vessels were considered as normal. They did not mention the dimensions of the vessels.

Table 10: Comparison of mean diameter of anterior cerebral artery according to sex

Authors	Side	Diameter (mm)	
		Male	Female
Kawther A. Hafez <i>et al</i>	Right	1.9	1.8
	Left	1.8	1.7
	Both	1.8	1.8
Krabbe-Hartkamp <i>et al</i>	Right	2	2
	Left	1.9	1.9
	Both	2	1.9
Present study Group A	Right	2.474	1.988
	Left	2.555	2.310
	Both	2.517	2.156
Present study Group B	Right	2.443	2.048
	Left	2.555	2.321
	Both	2.5	2.186

In the present study on statistical analysis, there was significant difference in the mean diameter of right and

left anterior cerebral artery according to sex. In both group A and group B, males had mean diameter more than the females on both right and left side as shown in table no 10. The mean diameter was maximum for the left side of anterior cerebral artery in males while it was minimum on the right side in the females. In the study by Krabbe-Hartkamp *et al*⁹, larger mean diameters were evident in males but they were not statistically significant for the anterior cerebral artery. Similar to our study the mean diameter of anterior cerebral artery was smaller in the females than in the males in the study by Kawther A. Hafez.¹¹ The study of the length, in relation to their diameter has assumed importance regarding flow of the blood in that vessel. The characteristics flow in the vessel segments, is caused by their tortuosity and small length, in relation to their diameter. Though more radiographic literature is available regarding such studies on length and diameter, cadaveric study in recent times to support the radiological conclusions are rare.¹² This study potentiates the radiological finding carried out on length and diameter of anterior cerebral artery and can be used as baseline study providing reference value to carry out further research on anterior cerebral artery.

CONCLUSION

From the present study following conclusions were derived.

1. Length: There was highly significant statistical difference in the mean length of right and left anterior cerebral artery. From this study it was observed that the Anterior cerebral artery have, in a majority of cases, a greater length on the right side.
2. Diameter: There was highly significant statistical difference in the mean diameter of right and left anterior cerebral artery.

The knowledge of the normal length and diameter of these vessels is useful to the surgeons in assessing the feasibility of shunt operations and in the choice of patients. For better understanding of the Circle of Willis in patients with various degree of carotid artery stenosis,

we aimed first to establish normal reference value of the measurable parameters and range of morphological variation of the circle in apparently normal population.

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