Diameter of Anterior Cerebral Artery - An Anatomical Study

Aggarwal N, * Paul M M, Mukherjee M, *****

* Assistant Professor, Department of Anatomy, Adesh Institute of Medical Sciences and Research,Bathinda.(Punjab).
** Professor, Department of Anatomy, Christian Medical College and Hospital, Ludhiana. (Punjab).
, *** Assistant Professor, Department of Anatomy, Christian Medical College and Hospital, Ludhiana. (Punjab).

Abstract: Background & objectives: The anterior cerebral artery is the smaller of the two terminal branches of the internal carotid. The cerebral arteries lie between their origins and their junctions with the corresponding communicating arteries. The haemodynamics of the circle of Willis is influenced by variations in the caliber of the segments of the anterior and posterior cerebral arteries and their communicating arteries. Arteries forming parts of circle of Willis frequently vary in size. Methods: In the present study the diameter of A1 segment of anterior cerebral artery, forming the anterior part of the circle of Willis, is measured in the brains of 50 embalmed cadavers. . The measurements of the diameters of the artery were taken using an electronic digital calliper with 300mm operating instructions (0.001mm accuracy). Results: The anterior cerebral artery at point 'A 'has a diameter of 2.79mm and 2.39mm on left and right sides respectively and at point 'B ' it has a diameter of 2.73mm and 2.38mm on left and right sides respectively. Interpretation & conclusion: The findings suggest that the left anterior cerebral artery has a larger diameter than the right anterior cerebral artery. The information regarding size and co-relation of the considered arteries may be useful for better interpretation of angiographic images and for deeper understanding of cerebral pathology. A knowledge of the normal size of these vessels may also be of use to the surgeon in assessing the feasibility of shunt operations and in the choice of patients. [Aggarwal N et al NJIRM 2013; 4(1) : 1-6]

Key Words: Diameter, anterior cerebral artery, vernier callipers

Author for correspondence: Dr.Navita Aggarwal, Department of Anatomy, Adesh Institute of Medical Sciences and Research, Bathinda. (Punjab).E- mail: navita22a@gmail.com

Introduction: The circulus arteriosus (circle of Willis) is a large arterial anastomosis at the base of brain which unites the internal carotid and vertebrobasilar system of arteries. The primary purpose of the vascular circle is to provide anastomotic channels if any vessel in the circle is occluded.

Anteriorly, the anterior cerebral arteries from both sides, which are derived from the internal carotid arteries, are joined by a small anterior communicating artery. The surgical nomenclature divides the vessels into three parts: A1 - from the termination of the internal carotid artery to the junction with the Anterior communicating artery; A2 – from the junction with the anterior communicating artery to the origin of the callosomarginal artery; and A3 – distal to the origin of the callosomarginal artery.[1]

Arteries forming parts of circle of Willis vary much in size. Depending on this, blood may or may not be easily shunted from one side of the brain to the other, or from the carotid to the basilar system or vice versa.[2] Vessels have been described as 'abnormally narrow', 'thread like', or 'string like' but actual diameters have rarely been measured, neither has it been stated what diameter could be considered abnormal.[3] Morphological and morphometeric investigation of these arteries may represent a valid basis for the evaluation of the commonest cerebral disorders as arteriosclerosis, cerebral hemorrhage and congenital aneurysm.[4]

Because of variations in the calibre of the vessels which form the circulus, it is therefore important, before tying off a carotid artery for any reason, to determine the nature of the circle by carotid or vertebral angiography, combined with compression of one or more of the feeding vessels to determine the efficacy of other parts of circle of Willis.[5]

Material and Methods: In the Department of Anatomy,at Christian Medical College, Ludhiana, 50 cadveric brains obtained at random from adult cadavers with intact circle of Willis were studied. The A1 segment of anterior cerebral artery which is one of the components of circle of Willis was observed for its diameter, variations, absence or the presence of multiple vessels. The measurements of the diameter of the artery were

taken using an electronic digital calliper with 300mm operating instructions (0.001mm accuracy). The diameter of A1 segment of anterior cerebral artery forming the part of circle of Willis was measured separately at following two points:

1. at its origin from internal carotid artery (taken as point 'A')
2. at the proximal part of its junction with anterior communicating artery (taken as point 'B').

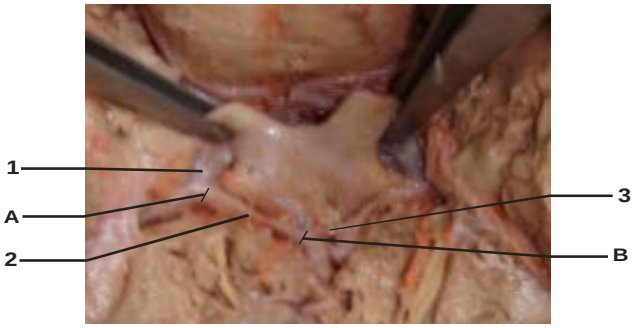
Fig 1. Equipment Used For Taking Measurements Of Anterior Cerebral Artery. (Electronic digital calliper with 300mm operating instructions (0.001mm accuracy)

In most of the brains the arachnoid mater of the interpedencular fossa was not present and in some where it was intact, it was very carefully lifted away from the structures to expose the A1 segment of anterior cerebral artery and anterior communicating artery. For taking the diameter at origin, the calliper was opened more than the diameter of the artery and introduced just at the point where anterior cerebral artery arises from the internal carotid artery. One of the prongs of the calliper was made to touch medial side of the right anterior cerebral artery and the other brought closer to approximate the lateral wall of the vessel. As soon as both the prongs touched the artery the calliper was locked taking care that the callipers does not distort the vessel wall and then the reading was recorded.

Then the diameter of left anterior cerebral artery was measured in the similar manner .

Then the area where anterior communicating artery was seen joining both the anterior cerebral arteries, was brought in view and at the point proximal to the anastomosis between the two anterior cerebral artery the diameter of the artery was measured on the right and the left side in the same way as above. In some cases there was double anterior communicating artery, and in those cases diameter of point 'B' was taken at junction of both anterior communicating artery and both readings were recorded for that measurement. All the measurements were recorded thrice on the same brains at three different occasions, and the three readings for each value were tabulated and average of each was taken for final comparison.

Fig 2. - ANTERIOR PART OF CIRCLE OF WILLIS IN CADAVERIC SPECIMEN SHOWING RIGHT AND LEFT ANTERIOR CEREBRAL ARTERY AND ANTERIOR COMMUNICATING ARTERY.



Point A – Origin of anterior cerebral artery from internal carotid artery.
Point B – Point of junction of anterior cerebral artery with anterior communicating artery.
No 1. - Internal carotid artery
No 2. - Anterior cerebral artery
No 3. - Anterior communicating artery

The data was tabulated and ANOVA statistics applied. Also, the anterior cerebral artery was noted for any other variations like hypoplasia, absent or multiple vessels.

Result: The results obtained have been given below.

Table 1. Diameter of anterior cerebral artery -A1 segment at its origin (at point 'A') in millimetres

Right		Left		p-value
Mean	SD	Mean	SD	
2.39	0.75	2.79	0.50	0.03

Fig – 3.: DIAMETER OF ANTERIOR CEREBRAL ARTERY – A1 SEGMENT AT ITS ORGIN (point – 'A')

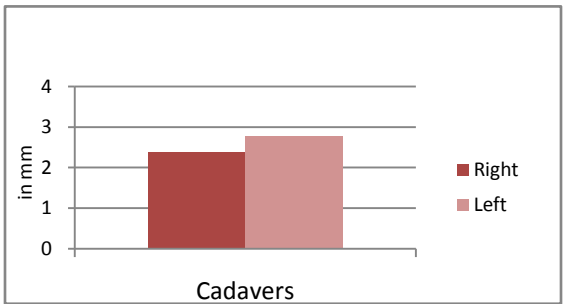
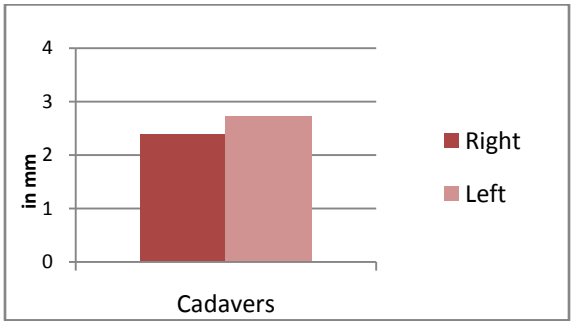


Table 2. : **Diameter of anterior cerebral artery- A1 segment at proximal part of its junction with anterior communicating artery (at point 'B') in millimeters.**

Right		Left		p-value
Mean	SD	Mean	SD	
2.38	0.75	2.73	0.58	0.06

Fig – 4. : DIAMETER OF ANTERIOR CEREBRAL ARTERY – A1 SEGMENT AT PROXIMAL PART OF ITS JUNCTION WITH ANTERIOR COMMUNICATING ARTERY (point 'B')



HYPOPLASIA IN A1 SEGMENT OF ANTERIOR CEREBRAL ARTERY : Considering the anterior cerebral artery of diameter less than 1.5mm as hypoplastic, the hypoplasia has been found to be in 8 out of 50 cases (16%) on right side and two out of 50 cases (4%) on left side. Therefore the hypoplasia is in 10 out of total 100 anterior cerebral artery – A1 segment studied, that is the hypoplasia is found to be 10 % in cadaveric brains.

Other Variations

No case of absent or multiple vessels in the A1 has been found on present study.

None of the cases showed doubling of any part of anterior cerebral artery whereas anterior communicating artery showed multiple vessels and doubling in few cases, but that is out of consideration in the present study.

DISCUSSION: Diameter at origin: The diameter of anterior cerebral artery at point 'A' ranges between 0.73mm - 3.72mm.The mean diameter on right side is 2.39mm ± 0.75mm and on the left side it is 2.79 ± 0.75mm.

Diameter of anterior cerebral artery at proximal part of its junction with anterior communicating artery: The range of diameter at point 'B' on right side is 0.51mm – 4.48mm.The mean diameter on right side is 2.38mm ± 0.75mm and on the left side it is 2.73 ± 0.58mm.

The point at which the diameter has been taken has not been specified in most of the above studies. In the present study it has been observed that the diameters on left side are slightly larger both at point 'A' and 'B' than that on the right side. The difference of diameter on right and left side have shown a significant p-value.

Pai et al [10], Mandiola et al [12], Kamath [3] observed that diameters on left are greater than right but they could not find a significant difference between the two sides. It has also been reported that large asymmetries in volume flow between the right and left is not necessarily caused by vascular disease but may be caused by variation in the anatomy of the circle of Willis like hypoplasia of A1 segment of anterior cerebral artery. [13]

The diameter below which the A1 segment could be called hypoplastic has not been well defined, but Perlmutter and Rhoton [7] used 1.5mm as the cut off figure for taking vessels as hypoplastic. They reported that 10% of the brains had the diameter of A1 segment less than 1.5mm and this finding corresponds to percentage of hypoplasia found in present study. Marinkovic et al [14] described hypoplasia to be of two types, mild and extreme hypoplasia. . Mild hypoplasia is in vessels with diameter less than 1.6mm and the difference of diameter on two sides to be 0.6 – 0.9mm in this type. Extreme hypoplasia is in vessels with diameter less than 0.9mm and the difference of diameter on two sides to be more than 1mm. He reported mild hypoplasia in 14% of cases and extreme hypoplasia in 8% of the cases.

Because of varying definitions of hypoplasia for A1 segment of anterior cerebral artery and because of different population groups being studied there is large variability in percentage of hypoplasia of this vessel in various studies.

In the present study we have been able to **obtain values of** diameter for North Indian population group, at origin of A1 segment of anterior cerebral artery and at proximal part of its junction with anterior communicating artery. This data can provide precise microanatomic information for surgical treatment of aneurysm or vascular reconstructive procedures in circle of Willis. [8] Also the anatomic parameters of anterior cerebral artery may be used to plan and design devices such as angiographic microcatheters and guides used in endovascular procedures.[9]An idea of normal dimensions of this vessel may contribute greatly to a surgeon's assessment of the feasibility of 'shunt operations'.

Table - 3. COMPARISON OF DIAMETERS OF A_1 SEGMENT GIVEN BY VARIOUS AUTHORS;

Author	Year	Diameter On Right Side	Diameter On Left Side
Murray[6]	1964	1.475mm	1.425mm
Perlmutter and Rhoton[7]	1976	2.6mm	2.6mm
Kamath[3]	1981	2.2mm +- 0.6mm	2.4mm +- 0.05mm
Gomes et al[8]	1986	2.3mm +- 1.0mm	2.5mm +- 1.0mm
Stefani et al[9]	2000	2.61mm +- 0.34mm	2.61mm +- 0.34mm
Pai et al[10]	2005	2.8mm	2.9mm
Vohra et al[11]	2006	1.44 mm +- 0.42 mm	1.44 mm +- 0.42 mm
Mandiola et al[12]	2007	2.37mm +- 0.68mm	2.42mm +- 0.75mm

It must be emphasized that a wider range of information on the size of the considered artery may be useful for a better interpretation of angiographic images and for deeper understanding of cerebral pathology. [4]

It is quite possible that in future, particularly in patients with asymptomatic severe carotid stenosis, the decision whether to operate or not will be influenced in part by the collateral ability of the circle of Willis and there these diameters may be used in prospective studies are evaluating the influence of collateral ability of circle of Willis on the development of ischaemic strokes in these patients as the rate of intraoperative cerebral ischaemia has been found to be significantly higher in patients with poor collateral circulation defined by the anatomy of circle of Willis. [15]

Abnormal narrowing of vessels was a common occurrence on the right side than on the left in this study. This may be related to the need for a better blood supply to the left hemisphere. This is because of dominance of left cerebral hemisphere in most of the population related to the handedness of the person. [16]

Although the clinical significance of anterior cerebral artery variations is usually minor, an associated aneurysm is found relatively frequently. Thus recognizing anterior cerebral artery diameter variation from the normal during the

interpretations of cranial angiograms is extremely important.[17]

Conclusion: Several factors can account for the variation in these results. First, the selected study populations differ (vessels in normal brains vs vessels in brains with evidence of neurovascular disease). Second, the methods and techniques of examination differ (anatomic dissection vs conventional contrast material enhanced angiography vs phase contrast or time of flight angiography). Third, investigators used set of criteria to define a normal or complete circle of Willis. The specific condition of a selective patient population may also contribute to variability

The recognition of the anatomic variations of the anterior cerebral artery and the detailed knowledge of the microvascular relationships of the aneurysms will allow the neurosurgeons to construct a better and safer microdissection plan to save time on the one hand and to prevent postoperative neurological deficits on the other.[18]

From the present and previous studies cited it is obvious that the values for diameter of anterior cerebral artery – A1 segment and frequencies of the variations differ from report to report. Since the studies come from various geographic regions and the subjects fall into varying groups of ages and sex, it is difficult to draw conclusions for general population.

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