

## ORIGINAL PAPER

# Calibre of the Component Vessels of the "Circle of Willis" of the Human Brain

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*Received on January 15, 2017; editorial approval on May 15, 2017*

## ABSTRACT

**Introduction:** The arteries of the circle of Willis (CW) of the human brain show considerable variations of calibre and pattern. Two pair of major arteries-right and left vertebrals; right and left internal carotids deliver all their blood almost exclusively to the brain. This arterial circle equalizes the pressure of the blood flow to the two sides of the brain as it's the main collateral channel. It provides alternative routes, when one of the major arteries leading into it is blockade. There is considerable individual variation in the pattern and calibre of vessels that make up the circle of Willis. **Material and methods:** The calibres of the different segments of the circulus arteriosus vary so much that no two circles are completely identical. Hence a study to determine the length and external diameters of the arteries constituting the CW in the population of Assam will be of utmost importance. The length and external diameters of the arteries forming the circle of Willis were measured. The recorded data were then statistically analysed using Student's T-test. P value < 0.05 is considered as statistically significant. **Result:** There is a statistical significant difference between diameters of both sided PCoA ( $t=2.123; P=0.041$ ) and the lengths of both sided A<sub>1</sub> ( $t=2.286; P=0.028$ ). **Conclusion:** The data obtained in this study will help in certain medico-legal practices. The study may be helpful to neurosurgeons and neurologists in Assam in planning and executing treatment of its population.

**Keywords:** Circle of Willis, length, external diameter

## INTRODUCTION

The brain is absolutely dependant on a continuous supply of oxygenated blood.<sup>1</sup> Two pair of major arteries-right and left vertebrals; right and left internal carotids deliver all their blood almost exclusively to the brain.<sup>2</sup> The circulus arteriosus (circle of Willis) is a large arterial anastomoses that unites the internal carotid and vertebrobasilar systems. It lays in the subarachnoid space within the deep interpeduncular cistern and surrounds

the optic chiasma, the infundibulum and other structures of the interpeduncular fossa. Anteriorly, the anterior cerebral arteries, which are derived from the internal carotid arteries, are joined by the small anterior communicating artery. Posteriorly, the two posterior cerebral arteries which are formed by the division of basilar artery are joined to the ipsilateral internal carotid artery by the posterior communicating artery.<sup>3</sup> The calibres of the different segments of the circulus arteriosus vary so much that no two circles are completely identical.<sup>4</sup> This arterial circle equalizes the pressure of the blood flow to the two sides of the brain as it's the main collateral channel.<sup>5</sup> It provides alternative routes, when one of the major arteries leading into it is blocked.<sup>6</sup> There is considerable individual variation in the pattern and calibre of vessels that make up the circle of Willis. Higher percentage of abnormality of length and diameter of the vessels of the circle of Willis has been reported in the mentally ill and those with cerebrovascular catastrophe indicating possible linkage.<sup>7</sup> Different distributions of variations of circle of Willis may partially explain the different incidences of some cerebrovascular diseases in different ethnic or racial groups.<sup>8</sup>

## OBJECTIVES

1. To study the length of both sides of the component arteries of circle of Willis in the population of Assam.
2. To study the diameter of both sides of the component arteries of circle of Willis in the population of Assam

## MATERIALS AND METHODS

**Collection of specimen:** (i) From the department of Forensic Medicine, Gauhati Medical College, Guwahati, from the cadavers

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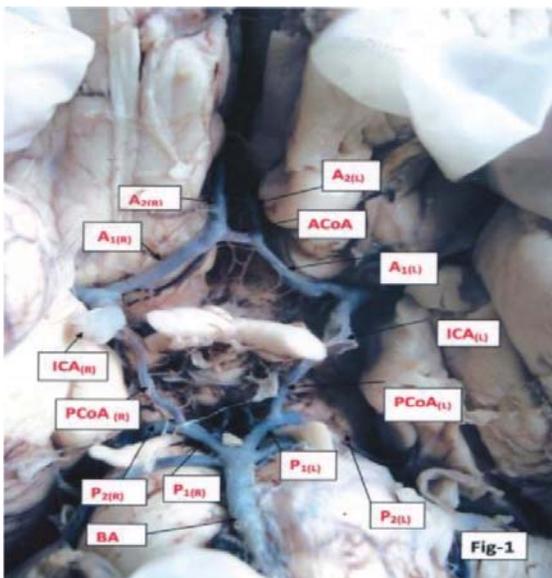
within stipulated time limit after fulfilling the formalities. Care was taken to collect the non-pathological specimens.

**Method of weighing & measurement:** Brains were first kept in 10% formalin and then washed with normal saline. Circle of Willis were dissected out and calibres were measured using Vernier Calipers.

**Analysis:** The data recorded was analysed statistically using Student’s T-test. P value d” 0.05 is considered as statistically significant

**OBSERVATION & RESULTS**

The results and observations of the present study is tabulated and graphed as follows:



**Figure 1** Circle of Willis



**Figure 2** Vernier Calipers

**Table 1** Descriptive Analysis of External Diameters (mm)of the Arteries of Circle of Willis

CW arterial segment	Mean	S.E.M	Median	SD	Minimum	Maximum
ACoA	1.56	0.12	1.40	0.68	0.40	3.10
PCoA <sub>(R)</sub>	1.43	0.15	1.30	0.78	0.10	3.10
PCoA <sub>(L)</sub>	1.07	0.11	1.10	0.58	0.20	2.50
P <sub>1(R)</sub>	1.67	0.12	1.75	0.73	0.20	3.40
P <sub>2(R)</sub>	1.63	0.12	1.60	0.61	0.20	2.90
P <sub>1(L)</sub>	1.81	0.11	1.85	0.65	0.20	3.30
P <sub>2(L)</sub>	1.74	0.12	1.90	0.64	0.10	3.10
A <sub>1(R)</sub>	1.93	0.12	1.85	0.68	1.0	3.40
A <sub>2(R)</sub>	1.85	0.11	1.75	0.62	1.0	3.80
A <sub>1(L)</sub>	2.01	0.14	2.0	0.83	0.60	4.70
A <sub>2(L)</sub>	1.81	0.11	1.85	0.65	0.50	3.10
ICA <sub>(R)</sub>	3.36	3.36	3.45	0.95	1.00	5.00
ICA <sub>(L)</sub>	3.34	3.34	3.40	0.69	2.00	4.40

**Table 2** Descriptive Analysis of Lengths(mm) of the arteries of the circle of Willis

CW arterial segment	Mean	SEM	Median	SD	Minimum	Maximum
ACoA	2.86	0.20	2.70	1.23	0.50	6.60
PCoA <sub>(R)</sub>	10.89	0.69	10.80	3.97	2.30	19.40
PCoA <sub>(L)</sub>	10.79	0.57	11.00	3.26	0.90	19.40
P <sub>1(R)</sub>	5.32	0.39	4.90	2.23	1.80	12.50
P <sub>1(L)</sub>	5.85	0.60	5.40	3.42	1.40	23.00
A <sub>1(R)</sub>	11.75	0.64	11.30	4.04	1.00	27.40
A <sub>1(L)</sub>	10.88	0.64	11.10	4.05	1.00	27.10

**Table 3** Paired t- test of the corresponding arterial segments of the circle of Willis

S No	Measures(mm)	t value	Df	P value(two tailed)
1.	Diameter of PCoA	2.123	33	0.041
2.	Diameter of A <sub>1</sub>	-0.325	40	0.747
3.	Diameter of A <sub>2</sub>	0.292	38	0.772
4.	Diameter of P <sub>1</sub>	-0.674	40	0.504
5.	Diameter of P <sub>2</sub>	0.292	38	0.772
6.	Diameter of ICA	-0.052	40	0.959
7.	Length of PCoA	0.138	31	0.891
8.	Length of A <sub>1</sub>	2.286	39	0.028
9.	Length of P <sub>1</sub>	-0.677	31	0.503

The data on the diameters and lengths of the branches of arteries of the circle of Willis have been statistically determined and described in **Table 1** and **Table 2** respectively. In **Table 3** the diameters and lengths of arteries of both sides of the corresponding arterial segments of the circle of Willis have been compared through Students paired t test assuming a level of statistical significance of P value less 0.05. There is a statistical significant difference between diameters of both sided PCoA (t=2.123;P=0.041) and the lengths of both sided A<sub>1</sub>(t=2.286,P=0.028). The average diameter of the right PCoA(1.34±0.75) was greater than of the left PCoA(1.08±0.56) and the average length of right A<sub>1</sub>(11.75±4.04) was greater than of the left A<sub>1</sub>(10.88±0.56).

**DISCUSSION**

Abnormal narrowing on the right half of the circle of Willis to be a more common occurrence. Present study showed that the length and diameter of the arteries forming the circle of Willis is variable which is similar to a Dissection Study on the length and external diameters of arteries of the CW by Kamath.<sup>8</sup> Similarly a Magnetic Resonance Angiography Study on the morphology of CW by Krabbe- Hartkamp<sup>9</sup> stated that the collateral potential of the circle of Willis is believed to be dependant on the presence and size of its component vessels, which vary among normal individuals. The blood supply of left half of the brain on the whole is less complete than to the right side according to Windle<sup>10</sup> and Mitterwallner.<sup>11</sup> The present study similarly showed statistically significant greater diameters on the right PCoA segments. However on the contrary Orlandini<sup>12</sup> found that the arteries to be larger on the left side of the circle of Willis. Warwick and Williams<sup>13</sup> found that the composite vessels of the circle of Willis in a majority of cases have a greater length and smaller diameter in the right half of the circle. In the present study only length of the right pre-communicating segment of anterior cerebral artery is significantly longer. Lacunae of the study lies in the fact that we could not find enough valid statistical evidence that

differences in calibres of the CW are similar among different populations done by other researchers or not. There should be cautious interpretations of the results of the quantitative measurements of the calibres of the arterial segments as the dissection studies have not been correlated with other advanced imaging modalities like Magnetic Resonance Angiography on live subjects.

#### CONCLUSION

The study showed that there are individual variations in the length and external diameters of the component arterial segments of the CW. Only the diameter of right PCoA and length of the right pre-communicating segment of anterior cerebral artery segment were statistically greater than of the left half of the CW.

**Conflict of interest:** None.

**Source of Funding:** None declared.

**Authors Contributions:** We declare that this work done by the authors named in this article and all liabilities pertaining to the claims relating to the content of this article will be borne by the authors. The study was conceived and designed by Dr. Farheen A. Karim, Dr. Kunja Lal Talukdar and Dr. Joydev Sarma. The data was collected and analysed by Dr. Farheen A. Karim.

**Acknowledgements:** We sincerely acknowledge the support of Dr. Rup Sekhar Deka, Associate Professor of Anatomy, GMC for his technical help.

#### REFERENCES

1. Turlough FMJ, Gruener G, Estomiah. Mtui. *Clinical Neuroanatomy and Neuroscience*. 5<sup>th</sup> ed. Philadelphia: Elsevier Saunders; 2007. p. 53.
2. Patetas MA, Leslie P, Gartner. *A textbook of Neuroanatomy*. 1<sup>st</sup> ed. Oxford: Blackwell Publishing; 2006. p. 99.
3. Standring S. *Gray's Anatomy*. 40<sup>th</sup> ed. London: Churchill Livingstone; 2008. p. 251-252.
4. Lazorthes G, Gouza A, Santini JJ, Salamon G. Le cercle arteriel du cerveau (circulus arteriosus cerebri) *Anat Clin* 1979;1:241-257.
5. Singh I. *Textbook of Human Neuroanatomy*. 9<sup>th</sup> ed. New Delhi: Jaypee; 2014. p. 41-42.
6. Kiernan JA. Barr's. *The Human Nervous System. An Anatomical Viewpoint*. Lippincott Williams & Wilkins. Philadelphia 2005;8:415-418.
7. Kamath S. Observations on the length and diameter of vessels forming the circle of Willis. *J Anat* 1981;133:419-423.
8. Eftthekar B. Are the distributions of variations different in different populations? - Results of an anatomical study and review of literature. *BMC Neurol* 2006;6:22(10)1186.
9. Krabbe-Hartkamp MJ. Circle of Willis: Morphologic variations on three-dimensional time-of-flight. *Magnetic Resonance Angiograms*. *Radiology* 1998;2007(1):103-11.
10. Windle BC. On the arteries forming the circle of Willis. *Journal of Anatomy and Physiology* 1887;22:289-293.
11. Mitterwallner F. Variationen statistische Untersuchungen an den Basalen Hirngefassen. *Acta Anatomica* 1995;24:51-57.
12. Orlandini GE. The ratified circumference of the principal arteries of the base of the brain. *Archivio italiano di anatomia e di embriologica* 1970;75:49-79.
13. Warwick R. & Williams PL. *Gray's Anatomy*. 35<sup>th</sup> ed. London: Churchill Livingstone; 1973. p 957.