A Study of Variation of Circle of Willis, in the Adult Population of South India

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ABSTRACT

Introduction: There is insufficient data on the variations of circle of Willis and cerebral circulation in the south Indian population. The aim of the study is to describe the most common variations found in the circle of Willis.

Material and methods: 50 embalmed cadaver brains were studied. The brains were dissected during the routine teaching of MBBS and BDS students. Detailed drawings of the circle of Willis were drawn and the photographs obtained using digital camera. Vernier caliper was used for measuring the length and external diameter of the vessels where they formed part of the circle of Willis.

Results: In 60% of brains, the circle of Willis is complete. The most common anomaly, is the occurrence of abnormal diameter of the arteries, and is found to be most frequent in the PCoA. The second most common anomaly is the absence of the component vessels; the PCoA is again most frequent. An uncommon anomaly observed is, in a brain specimen the right PCA is very thin and is dividing into slender branches after some distance. One of its branches is joining the hyperplastic anterior choroidal artery and the PCoA are absent on both sides.

Conclusion: In the south Indian population variations are in accordance with the literature and there appears to be no difference between races.

Keywords: abnormal arteries and absent arteries, non-classical morphology, hyperplastic anterior choroidal artery

INTRODUCTION

The circle of Willis is formed in the base of the brain, by the branches of both the internal carotids and the vertebral arteries. The arterial circle maintains continuous blood supply to the brain at all times. However, there exist many anatomic variations including different populations, resulting in the variation in the blood supply to the brain.

The normal circle of Willis or the circle of Willis with the classical morphology is the one, whose components include internal carotid arteries of both sides, its anterior cerebral arteries joined by the anterior communicating artery anteriorly and its posterior communicating arteries joining the posterior cerebral arteries.

The most common anatomic anomalies observed in the study are, the abnormal diameter of the vessels and the absence of the component vessels resulting in an incomplete circle or non- classical morphology of circle of Willis. Different studies put the occurrence of normal circle of Willis in the range between 28 to 52% in the different populations.[1,2]

The anatomic variations could be due to different races of populations is a question raised by Eflekhar, Dadmehr, Ansari et al., 2006[3] and Nordon DG and Rodrigues Junior OF.[4] The existing data on the anatomic variation in respect of the south Indian population is insufficient; and this study will contribute to our current knowledge in anatomical variations between different populations.

MATERIAL AND METHODS

The brains were obtained for the study from the Government Siddhartha Medical College, Vijayawada, south India and other nearby colleges. The study was done during 2004 to 2007 and in 2016 after obtaining ethical approval from the institutional ethical board.

The length and external diameter of the vessels were measured where they formed part of the circle of Willis i.e. the internal carotid between its posterior communicating and anterior cerebral branches, the anterior and posterior cerebrals from their points of origin to the point where they were joined by the communicating artery and the communicating arteries in their entirety.[5]

A caliper, graduated to measure up to 0.02mm was used. The arteries less than 1 mm in diameter were considered abnormal, barring communicating arteries, where less than 0.5 mm diameter was considered abnormal.[5]

The most important anatomic anomalies and variations are studied in detail. The basic criterion for considering the circle as anomalous was being unable to maintain an adequate blood flow, what is defined by Alpers, Berry and Paddison (1959) one in which, blood can circulate from any entrance point and return the same point.[4]

The abnormal arteries and the absent arteries are considered as anomalies as they give rise to incomplete circle of Willis. Other morphological differences which do not result in an incomplete circle of Willis are considered as anatomic variations.

STATISTICAL ANALYSIS

Microsoft excel was used to make tables. Descriptive statistics were used to infer results.

RESULTS

Among the brains studied 60% had no abnormal or absent arteries and the circle of Willis is complete. The main anatomic anomalies and variations observed are represented

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How to cite this article: A.Prasanna Veera Kumar, K. S. N. Prasad. A study of variation of circle of willis, in the adult population of South India. International Journal of Contemporary Medical Research 2016;3(5):1448-1450.

Artery	Anatomic variation/ anomaly		Number	%
ACoA	Double	Variation	2	4
ACoA	Abnormal diameter	Anomaly	4	8
ACA	Triple ACA in A2 segment / Accessory ACA generation	Variation	2	4
ACA	Anastomosis with the other ACA	Variation	4	8
Right ACA	Abnormal diameter	Anomaly	1	2
Right PCA	Abnormal diameter	Anomaly	1	2
Right PCA	Thin and dividing into slender branches / Uncommon origin from ICA	Anomaly	1	2
Left PCA	Abnormal diameter	Anomaly	1	2
Right PCoA	Abnormal diameter	Anomaly	4	8
Left PCoA	Abnormal diameter	Anomaly	2	4
Right PCoA	Absent	Anomaly	2	4
Left PCoA	Absent	Anomaly	2	4
Both PCoA	Absent	Anomaly	2	4

Table-1: Showing anatomic anomalies and variations.

in the Table 1.

The most common anomaly in the study is the occurrence of abnormal diameter of the arteries. It is most frequently seen in the PCoA. Out of the six observed (12%), four are present on the right side (8%) and two on the left side (4%). The ACoA is of abnormal diameter in (8%), the PCA has two abnormal arteries one on each side (4%) and ACA has one present on the right side (2%).

The second most common anomaly observed is the absence of component vessels; the PCoA is absent in 12%; both sides absent in 4%, left side absent in 4%, right side absent in 4%. An uncommon anomaly observed in the study is, in a brain specimen the right PCA is very thin and is dividing into slender branches after some distance. One of its branches is joining hyperplastic anterior choroidal artery and PCoA are absent on both sides (Figure-1).

The variations which did not affect the circle and observed in the study include: the ACA has anastomoses between them in 8% (Fig. 2), a third ACA or an accessory ACA generation in A2 segment in 4%, and the ACoA is double in two specimens (4%).

The Table 2 shows the distribution of non-classical morphology observed in the study, which is 40% (100%), and it is found that most of the non-classical morphology existed in the posterior circulation with 75 %; on the right side of brain 50%; in the anterior circulation 25% out of which the median is 20 %.

Side	Anterior	Posterior	Total
Left	0(0%)	6(30%)	6(30%)
Right	1(5%)	9(45%)	10(50%)
Median	4 (20%)	0(0%)	4(20%)
Total	5(25%)	15(75%)	20 (100%)

Table-2: Showing number of alterations per location. N%.

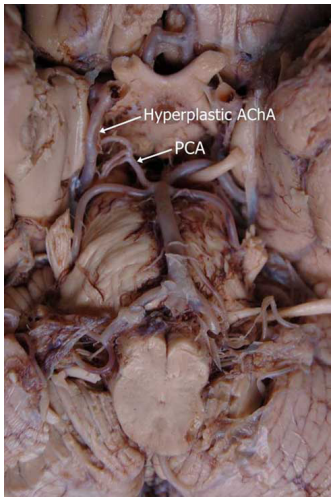

Figure-1: Showing the right PCA dividing into branches and a branch joining the hyperplastic AChA and absence of PCoA on both sides.

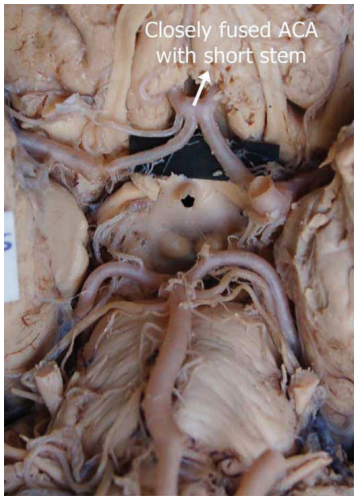

Figure-2: Showing fused ACA with a short stem.

DISCUSSION

The number of brains with non-classic morphology is 40%. The non- classic morphology according to the literature ranged between 48% -71.7%.[1,2]

In the anterior circulation, the ACoA is of abnormal diameter in (8%). This is quite significant because according to literature rarely (1%) of the ACoA is aplastic.[3,6] The ACA has anastomoses between them in 8% with a short fused A2 trunk and one among the ACA is found to be dominant in the A2 segment. A fused short A2 trunk is more commonly found.[4] In the A2 segment of the ACA, one ACA is found to be dominant and provides blood supply to both hemispheres in its distal aspect of the cerebral hemispheres.[6] The third ACA or an accessory ACA generation in A2 segment in the study is found in two brain specimens (4%) and is found

to be originating from the ACoA. This represents our most common finding in the anterior circulation; with 3 cases of "extra ACA", they were all originated directly from the ACoA.[4] The ACoA is double in (4%). The ACoA, may be duplicated or differently fenestrated.[6] Duplications or triplications are most common in the anterior circulation (19%).[1]

In the posterior circulation, the abnormal diameter of the arteries is found to be the most frequent in PCoA with (12%). The PCoA are hypoplastic with external diameter smaller than 1mm in 12% to 60% of the cases.[3] The absence of PCoA in the study is 12%. The PCoA variations are regarded as the most common variations in brain circulation; they are missing in 10% to 46% of the cases.[3]

An uncommon anomaly found in the study is in a brain specimen the right PCA is very thin compared to the contralateral side and is dividing into slender branches after some distance. One of its branches is joining the hyperplastic anterior choroidal artery. The normal AChA has potential anastomoses with its neighbouring arteries, especially with the PCoA and PCA.[7-10] Hyperplasia of the AChA seems to represent a situation in which one of those anastomoses remains and enlarges as a main pathway of the artery, while a segment of the PCA just proximal to the anastomosis eventually attenuates.[11] The specimen is illustrated in the Figure-1.

Differences between races

In the study no major differences in the anatomic variations in the south Indian population are found. According to the literature there are no differences between races in the anatomic variations.[2,3,6] The differences that are reported may have arisen due to differences in the embryonic development of brain and other variable factors which includes the genetic, environment and hemodynamic etc. The origin of variations needs further study by radiology and other noninvasive methods.

CONCLUSION

In the south Indian population, variations in the posterior circulation of the brain are 30% and in the anterior circulation 10%. These result in an incomplete circle of Willis, which has important clinical impact. The variations are more on the right than on the left side of the brain. There seems to be no difference between races.

ACKNOWLEDGEMENT

Authors sincerely thank the Professor and HOD's of Kakathiya Medical College, Warangal, Pinnamaneni Siddhartha Medical College, Chinoutpalli, Gannavaram and NRI Medical College, Chinnakakani, Guntur, for their support.

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Source of Support: Nil; **Conflict of Interest:** None

Submitted: 27-03-2016; **Published online**: 26-04-2016