Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/17776
DOI URL: http://dx.doi.org/10.21474/IJAR01/17776

*RESEARCH ARTICLE*

# VARIATIONS OF CIRCLE OF WILLIS - DIGITAL SUBTRACTION ANGIOGRAPHIC STUDY IN A SOUTH INDIAN POPULATION

**Dr. Vinod Kumar T.[1], Dr. Pradeep T.T MCh[1], Dr. R. Venkatesh MCh[2], Dr. Anandha Shanmugaraj MCh[3], Dr. G. Murugesan[3] and Dr. K. Indunesh MCh[2]**

1. Assistant Professor, Department of Neurosurgery, CMCH.
2. Professor, Department of Neurosurgery, CMCH.
3. Associate Professor, Department of Neurosurgery, CMCH.

## Manuscript Info

***Manuscript History***
Received: 28 August 2023
Final Accepted: 30 September 2023
Published: October 2023

***Key words:-***
Circle Of Willis, Variations, Aplasia, Hypoplasia

## Abstract

**Background:** The Circle of Willis is an arterial polygon at the base of the brain, forming a vital collateral network for adequate cerebral perfusion. The pattern and caliber of vessels that comprise the circle show considerable individual variation. Some of these changes may increase the risk of formation of aneurysm and alter the severity of symptoms of cerebrovascular diseases, like stroke and infarcts.

**Objectives:** The aim of this study is to analyse the variations of the circle of Willis with the help of digital subtraction angiography

**Methodology:** This cross-sectional study was conducted in the department of Neurosurgery, Coimbatore Medical College Hospital, for a period ranging from January 2021 to March 2023. Patients admitted to undergo digital subtraction angiography (DSA) for various indications were included in this study. Circle of Willis was analyzed with reference to complete or incomplete circle, asymmetry in configuration, variations in size, presence of multiple anomalies and type of anomaly.

**Results:** Morphology of the Circle of Willis and its variations were studied in digital subtraction angiography (DSA) of 188 patients. Normal pattern was noted in 118(62.76%) and the remaining 70(37.24%) had one or more variations; 56(80%) had variations in anterior circulation and 14(20%) had variations in posterior circulation. Variations on the right were 28(40%) while 40(57.14%) were on the left. Incomplete circle was found in 22(31.42%). In 124 cases aneurysms were observed.

**Conclusion:** Variation in the morphology of circle of Willis is common, with the most common being variation in the PCom in this study.



## Introduction:-

Human brain isa complex organ with billions of specialized cellswhich make it a vitalpart of the human body, being supplied extensively with blood vessels. Brain receives blood supply from internal carotid and vertebral arteries,connected by an anastomotic network - Willis polygon,located in the interpeduncular fossa at the base of the

**Corresponding Author:- Dr. Vinod Kumar T.**
Address:- Assistant Professor, Department of Neurosurgery, CMCH.

brain, named after a British Anatomist-Physician Thomas Willis[9]. A classicalcircle of Willisis described as a bilaterally symmetrical, completering of vessels[4].

But, the pattern and caliber of vessels that comprise the circle show considerable individual variation. Although the circular channel is almostalways complete, one or more vesselsare usually narrowed to reduce their role as a collateral route and thecircle is rarely functionally complete.Most of the variation betweenindividuals occurs in theposterior communicatingartery, which is normally very small, permitting onlyminimal flow between the anterior andposterior circulations.

Often, there may be variations in the configurationof the vessels or the vessels maybe hypoplastic, duplicated andsometimes absent[2]. These variations often play a significant rolein cerebrovascular diseases. Any change in the normalmorphology of the circle may determine the severity of symptoms of cerebrovascular disorders,such as stroke, aneurysms,infarcts and other vascularanomalies.

It is a well-established fact that the adequacy andcompliance ofcollateral circulation plays a vital role inthe course and severity of a cerebrovascular disorder.Analysing and establishing the pattern of circle of Willisis an important prerequisite of variousdiagnostic and therapeutic neurovascular procedures.Detailed knowledge of theseabnormalities isessential to neurologists and neurosurgeons in planning for various procedures.These problems make it imperative to have a detailed knowledge of these variations of arterial anatomy and to correlate themwith the occurrence of aneurysms, strokeand otherarterio-venous malformations.

## Methodology:-

This cross sectional study was conducted in the department of Neurosurgery, Coimbatore Medical College Hospital, during the period ranging from January 2021 to March 2023. Patients with spontaneous subarachnoid hemorrhage and unruptured aneurysms, admitted to undergo digital subtraction angiography (DSA)were included in this study. Circle of Willis was analyzed withreference to complete or incomplete circle,asymmetry in configuration, variations in size, presence of multiple anomalies and type of anomaly. Kamath'sobservations were followed in defining various arterial parameters. Arteries were considered hypoplastic when diameter wasless than 1mm in case of cerebral arteries and less than 0.5 mmforcommunicating arteries.

## Results:-

Morphology and variations of circle of Willis werestudied in 188 patients who underwent digital subtractionangiography (DSA). Out of 188 cases, 89(47.34%) were males and 99(52.66 %) were females. Most of the patients 56(29.79%)belonged to 60–69 years age group, among them about 28(14.89%) were male and 28(14.89%) were female. (Table 1)

**Table 1:-** Distribution of the Study Population by Age andGender (n=188).

| Age (in years) | Male | Female |
|---|---|---|
| 10-19 | 1 | - |
| 20-29 | 2 | 1 |
| 30-39 | 7 | 5 |
| 40-49 | 26 | 24 |
| 50-59 | 23 | 32 |
| 60-69 | 28 | 28 |
| 70-79 | 1 | 7 |
| 80-89 | 1 | 2 |
| **Total** | **89 (47.34%)** | **99 (52.66%)** |

It was observed that among males, 62(32.98%) had normal circleof Willis and27(14.36%) had abnormal circle ofWillis. Among females, 61(32.44%)had normal circle of Willis and 38(20.22%) had abnormal circle of Willis.(Table 2)

**Table 2:-** Distribution of the Study Population by Variationof Circle of Willis (n=188).

| | Normal | Abnormal | Total |
|---|---|---|---|
| Male | 62 (32.98%) | 27 (14.36%) | **89 (47.34%)** |
| Female | 61 (32.44%) | 38(20.22%) | **99 (52.66%)** |

| | | | |
|---|---|---|---|
| **Total** | **123 (65.42%)** | **65 (34.58%)** | **188** |

A total of 70 variations were found among the 65 patients found to have abnormal circle of Willis. Out of the 70 variations, 56(80%) variations were in the anterior circulation and 14(20%)variations were observed in the posterior circulation.More variations were observed on the left side thanon the right side. 40(57.14%)variations were observed onthe left side as compared to 28(40%)variations onthe right side. (Table 3)

**Table 3:-** Distribution of the Study Population by Variation(n=70).

| Group | Name of artery | Distribution | Range | | Frequency |
|---|---|---|---|---|---|
| **Anterior cirvculation** | ACA(A1) | right | 5 | 26 | 37.14% |
| | | left | 21 | | |
| | ACom | | 2 | 2 | 2.86% |
| | PCom | right | 18 | 28 | 40% |
| | | left | 10 | | |
| **Posterior circulation** | PCA(P1) | right | 5 | 14 | 20% |
| | | left | 9 | | |
| **Total** | | | **70** | **70** | **100%** |

Anterior cerebral artery variations were observed in 26(37.14%) among the 70variations. HypoplasticA1 segment was noted in 14(20%) cases, among which 9 were found on the left side and 5 on the right side.Aplastic A1 segment was noted in 12(17.14%) cases, all on the left side. Aplasia of the anterior communicating artery was noted in 2(2.86%) patients.

Highest number ofvariations was observed in the posterior communicating artery, 28(40%) of the70variations. Hypoplasia was the commonest variationobserved in this artery. 4(5.71%) cases had completeabsence of posterior communicating artery, on the right side. 24(34.29%) cases had hypoplastic posterior communicating artery. In 14 cases it wasnoticed onthe right side and in 10 cases, on the left.

Further, 14(20%) variations were found in the posterior cerebral arteries. Absence ofP1 segment was observed in 4(5.71%), all on the left side. Hypoplastic P1segment was observed in 10(14.29%) cases, 5 on the left and 5 on the right side.(Table 4).

**Table 4:-** Distribution of the study population by name ofartery, nature,distribution, number and percentage ofvariation with variants (n=70).

| Name of artery | Nature and distribution | Frequency | | Percentage |
|---|---|---|---|---|
| **ACA (A1)** | **Hypoplastic (left)** | **9** | **14** | **20%** |
| | **Hypoplastic (right)** | **5** | | |
| **ACA (A1)** | **Aplastic (left)** | **12** | **12** | **17.14%** |
| | **Aplastic (right)** | **0** | | |
| **ACom** | **Duplication** | **0** | **2** | **2.86%** |
| | **Aplastic** | **2** | | |
| **PCom** | **Hypoplastic (left)** | **10** | **24** | **34.29%** |
| | **Hypoplastic (right)** | **14** | | |
| **PCom** | **Aplastic (left)** | **0** | **4** | **5.71%** |
| | **Aplastic (right)** | **4** | | |
| **PCA (P1)** | **Hypoplastic (left)** | **5** | **10** | **14.29%** |
| | **Hypoplastic (right)** | **5** | | |
| **PCA (P1)** | **Aplastic (left)** | **4** | **4** | **5.71%** |
| | **Aplastic (right)** | **0** | | |

| | | | | |
|---|---|---|---|---|
| **Total** | | **70** | **70** | **100%** |

Among 65 abnormal circles, 22 (31.42%) wereincomplete due to aplasia of vessels. (Table 5).

**Table 5:-** Distribution of the study population by thepattern of incomplete circle of Willis (n=65).

| Name of artery | Distribution | Frequency | Percentage |
|---|---|---|---|
| **ACA(A1)** | **left** | **12** | **18.46%** |
| | **right** | **0** | **0** |
| **ACom** | | **2** | **3.09%** |
| **PCom** | **left** | **0** | **0** |
| | **right** | **4** | **6.15%** |
| **PCA(P1)** | **left** | **4** | **6.15%** |
| | **right** | **0** | **0** |
| **Total** | | **22** | **33.85%** |

Out of total 65 abnormal circle of Willis in this series, multiple anomalies were observed in 4(6.15%) circles. Among the multiple anomalies, 3(4.62%) circles had two anomalies. More than two anomalies were observed in 1(1.53%) circle.

## Discussion:-

The Circle of Willis exhibits significant individual variation in the patternand the caliber of vessels that constitute the circle. These variations differfrom individual to individual. The arteries may show variation on either side of the same individual. The prevalence of the classic Willis polygon rangesfrom 4.6% to 72.2%.This wide range maybe due to different criteria used to define hypoplastia of vessels. In the present study, Kamath's observations were followed. Arteries were considered hypoplastic when diameter wasless than 1mm in case of cerebral arteries and less than 0.5 mmforcommunicating arteries[5]. Inspite ofnumerous studies, the reason why the variations occur has not been clearly established.

Many theories have been proposed to explain the variations of circleof Willis. Lazorthes et al[6]theorised that the amplitude of neck movements influenced the variations of the segments. Milenkovic et al[7]observed thatthese variations and anomalies are genetically determined and develop in the embryonic stage. Van-Overbeeke et al[10]observed that trapid growth of occipital lobes led to variations in the posterior circulation. The circle offers a potential shunt in case of spasm or occlusion of vessels.Thepossibility of bypass/shunt in occlusion of one of thecerebral vessels and the recovery or worsening after vascular occlusions may be explained partly by variations in theanatomy of the circle ofWillis.

The findings of the present study with respect to the normalpattern of circle correlate with the cadavericstudy of Alpers et al, Stephen andJohn . A cadaveric study byRaghvendraet al[8]noted that variations weremore common in the posteriorcirculation which differs with the present study. Maximum variations were noted inthe posterior communicating artery. The findingsof the present study are approximately similar to thecadaveric study findings of Pedroza et al[1], with respect to the hypoplasia of posterior communicating artery.

In the present study, the prevalence of variations isapproximately four times more in the anterior circulation than in the posterior circulation. The variations aremore prevalent on the left than on the right side.Incomplete circle of Willis is found in 22 cases. Of the 188 patients who underwent DSA, aneurysms were diagnosed in 124 patients. Posteriorcommunicating artery shows the most variation in the present study, and the most commonvariation being hypoplasia.

## Conclusion:-

A thorough knowledge of the variations will improve the success of any interventional procedure. Theanomalies of the circle play an importantrole in the occurrence, manifestation of symptoms, severity andrecovery process of certaincerebrovasculardisorders such as stroke, infarcts andaneurysms. The knowledge of these anomalies willhelp in the understanding of pathophysiology,angio-architecture and haemodynamics of the lesions.

## References:-

1. Alfred Pedroza, Manuel Dujovny, Jose Cabezudo Artero.Microanatomy of the posterior communicating artery. J Neurosurg1987; 21 (2): 228-35
2. Alpers BJ, Berry RG,Paddison RM. Anatomical studies of thecircle of Willis in normal brain. Arch Neurol Psychiat.1959; 81:409 – 18
3. Hendrikse J, Hartkamp MJ, Hillen B, Mali WP, van der GrondJ. Collateral ability of the circle of Willis in patients withunilateral internal carotid artery occlusion: border zone infarctsand clinical symptoms.Stroke. 2001;32(12):2768-73.
4. Iqbal S. A Comprehensive Study of the Anatomical Variations of
the Circle of Willis in Adult Human Brains. J Clin Diagn Res.2013;7(11):2423-27
5. Kamath S. Observations on the length and diameter of thevessels forming the circle of Willis. J Anat.1981; 133: 419 – 23
6. Lazorthes G, Gouaze A, Santini JJ, Salamon G. The arterialcircle of the brain (circulus arteriosus cerebri). Anatomica Clinica.1979; 1:241-57
7. Milenkovic Z, Vucetic R, Puzic M. Asymmetry and anomaliesof the circle of Willis in fetal brain.Microsurgical study andfunctional remarks. Surg Neurol. 1985; 24(5): 563-70
8. Raghavendra, Shirol VS, Daksha Dixit, Anil Kumar Reddy Y,Desai SP. Circle of Willis and its variations; morphometric study inadult Human cadavers. Int J Med Res Health Sci.2014;3(2):394-400
9. Samuel M. Wolpert. History of the circle of Willis. Am JNeuroradiol. 1997; 18;1033-34
10. Van Overbeeke JJ, Hillen B, Tulleken CA. A comparative studyof the circle of Willis in fetal and adult life. The configuration ofposterior bifurcation of the posterior communicating artery. J Anat.1991;176:45-54.