# Classical Pattern of the Cerebral Arterial Circle of Willis in a Nigerian Population Using Contrast Enhanced Computed Tomography Scan.

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## Abstract

Studies have highlighted the significance of patterns of the circle of Willis (major arterial supply to the brain) observed from different parts of the globe. This research was carried out to identify and document the patterns of the cerebral arterial circle of Willis, which are lacking in the Nigerian population. A total of 512 normal brain CT images of Contrast Enhanced Computed Tomography (CECT) scans from the CT scanner in the Radiology Department of Jos University Teaching Hospital (JUTH) were obtained and reviewed using proportionate random sampling probability technique with their ages graded from <1 year to >91 years between January 2013 to July 2015. Data collected out of the 512 brains examined showed that the commonest pattern was 39.84%, which conforms to the classical, standard or complete circle of Willis with all the vessels intact as those in the text books of Anatomy while the rest (60.16%) were observed to be morphologically incomplete circle of Willis. The CECT scan method has established for the first time the occurrence of forms of the circle of Willis in a Nigerian sampled population with the classical pattern (39.84%) as the most common. This finding agrees with reports from studies with cadaveric Gross Dissection (GD), Magnetic Resonance Imaging (MRI) and the injection techniques.

**Keywords:** CECT Scan, Classical, Circle of Willis, Morphological, Nigeria, Pattern.



## 1. Introduction:

*Circulus arteriosus cerebri* Willisii is the official description of the cerebral arterial circle of Willis, also known as the Willis polygon, Willis' circle or loop of Willis ''[1]''. The circle of Willis, first described by a seventeenth century English Physician "Dr. Thomas Willis", in 1664, is located at the root of the substance of the brain between the two vertebral arteries of the vertebrobasilar system and the right and left internal carotid arteries that supply the brain ''[2], [3]''. It is however formed by the right and left posterior cerebral arteries, the right and left posterior communicating arteries, the right and left internal carotid arteries, the right and left middle cerebral arteries, the right and left anterior cerebral arteries and a single anterior communicating artery, respectively ''[3]''. Configuration of the brain arteries into the Willis' circle provides collateral in the distribution of blood such that if a portion of it becomes occluded or if one of its arterial supply is thinned, the flow of blood from other arteries can maintain adequate cerebral distribution thereby preventing symptoms from conditions like ischaemia ''[4]''.

According to Bergman (2005), the classical pattern of the Willis' circle was only seen in about 34.50% cases, this was based on a composite review of 1,413 human brains in Tokyo by Adachi in 1928 who carried out a study on the Japanese arterial system ''[5]''. Similarly, the works of Riggs and Rupp (1963), Krabbe-Hartkamp and Vander (2000), De Silva *et al.* (2011) and Saikia *et al.* (2014) on "Incidence of the normal pattern

of circle of Willis", examined 994, 150, 225, and 140 human brains from the United States of America (USA), Netherlands, Sri Lanka and the Indian populations, observed 21.00%, 42.00%, 22.14% and 14.20% respectively ''[6], [7], [8], [9], [10], [11]''. Studies in the fields of Anatomy and Radiology have equally shown that more than 50.00% of healthy individuals are characterized with morphological patterns in the Willis' circle, including the study of about 100 human brains carried out in East Azerbaijan of the Iranian population ''[12]''. Also, these patterns are clinically significant in cerebral haemodynamics, where they act as collateral anastomotic network '' [13], [14], [15]''. Studies on patterns of the Willis' circle from the different racial populations as earlier stated, based on the Magnetic Resonance Imaging (MRI), the cadaveric Gross Dissection (GD) and also with the injection techniques have been conducted, meanwhile, these have not been documented at all in Nigeria. Hence, the rationale for this research which is to identify and document the patterns of the circle of Willis in a Nigerian sampled population using contrast enhanced brain Computed Tomography (CT) scan images.

## 2. Materials and methods:

A Bright speed 4-slice CT scanner with Model number – 5143665, Serial number - 16507017m4, Model number of tube – 5140014, Serial number of tube -165074Hm6, Manufacturer – General Electric (GE), Maximum kiloVoltage power (kVp) 140, Maximum milliAmpere seconds (mAs) 300, Date of manufacture, 2007 with the equipment standardized according to the manufacturer's specifications as obtained from the Medical Physics unit of the Radiology Department, Jos University Teaching Hospital (JUTH). A retrospective and prospective research design conducted on 512 apparently normal brain CT images consisting of 286 (55.86%) males and 226 (44.14%) females with their ages graded from <1 year to >91 years, reviewed between January 2013 to July 2015. Axial sections of the brain (Plate 1) were obtained from the base of the skull to its vertex with slice thicknesses of 2.5mm following the intravenous administration of about 10 – 40mls Ultravist (contrast medium) through the anti-cubital vein for enhancement of the vessels (circle of Willis). Images were carefully observed with the component vessels noted (Figure 1). A proportionate (stratified) random probability method was employed. Data were obtained in accordance with the institutional guidelines following ethical permission, approval and clearance granted by the Committee on Research Ethics, JUTH.



## 3. Results:

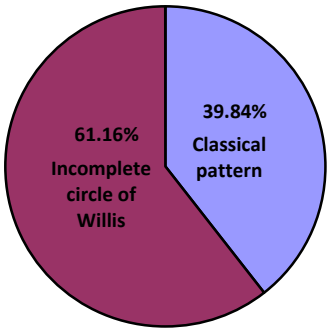


Figure 1: Percentage distribution of circle of Willis pattern observed amongst a Nigerian population.

Figure 1 shows axial CECT scan of the brain at the level of posterior cliniods, demonstrating a hyperdense (enhanced) brain arteries which include a single anterior communicating that connects the right and left anterior cerebral with a paired internal carotid. Originating from the Internal Carotid Artery (ICA) are the right and left posterior communicating arteries that joins the right and left posterior cerebral arteries, and a single basilar artery as indicated by the arrows. This description defines the classical, standard or complete pattern of the cerebral arterial circle of Willis.

Table 1
Studies on Classical Pattern of the circle of Willis

| Technique | Country | No. of brains Examined | Percentage (%) | Year | Author |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| GD | USA | 994 | 21.00 | 1963 | Riggs & Rupp |
| MRI | Netherland | 150 | 42.00 | 2000 | Krabbe-Hartkamp & Vander |
| GD | India | 1,000 | 45.20 | 2003 | Kapoor |
| GD (composite review) | Japan | 1,413 | 35.50 | 2005 | Bergman |
| GD | Sri Lanka | 225 | 14.20 | 2011 | De Silva *et al.* |
| Gross specimen + MRI | India | 140 | 22.14 | 2014 | Saikia *et al.* |
| CECT scan | Nigeria | 512 | 39.84 | 2016 | Present study |

## 4. Discussion:

Results from our study showed that the commonest pattern of the circle of Willis was the classical, complete or standard (Plate 1), where all the vessels as those in textbooks of anatomy are present. This accounts for 39.84% of the 512 apparently normal brains examined while the rest showed different morphological patterns (60.16%). This observation supports the report of ‘’[10]’’ who studied 1,000 brains using the GD technique to record 45.20% complete pattern with 54.80% incomplete circle of Willis noted (table 1). Result of the present study also agrees with ‘’[8]’’ who conducted a research on 150 Netherland subjects using the MRI technique and ‘’[5]’’ who carried out a composite review of about 1,413 human brains of the Japanese population using the GD technique to obtain 42.00% and 35.50% classical patterns with 58.00% and 64.50% incomplete circle of Willis noted respectively.

The commonest (classical) pattern of the cerebral arterial circle of Willis observed by authors (table 1), has a wide range of prevalence from as low as 14.20% observed in the Sri Lankan population to as high as 45.20% recorded from the Indians. In the present study, the classical pattern was 39.84% with 60.16% morphologically incomplete circle of Willis noted. This result is closely related to the findings of ‘’ [10], [8], [5]’’ who recorded 45.20%, 42.00% and 35.50% from the Indians, Netherlands and the Japanese populations respectively. Also, the result obtained from our study is similar to studies by ‘’ [7], [9], [6]’’ who observed a significant low distribution of 22.14%, 21.00% and 14.20% respectively. Table 1 also shows that the classical pattern diverges widely among the different racial populations irrespective of the technique (method) employed. However, postulations as to the underlying reasons for this variability may not have been accounted for in the present study. Meanwhile, result of the present study may contribute positively to pattern recognition and interpretation of cranial vessels in relation to diagnosis and also, during neurosurgical interventions of the cerebral arterial circle of Willis in the study Nigerian population.

## 5. Conclusion

In conclusion, the CECT scan method has demonstrated patterns of the Willis’ circle in a Nigerian population with the commonest form (39.84%) which conform to the classical (complete) circle of Willis where all the vessels are intact as those in the text books of Anatomy. This finding agrees with reports from studies with cadaveric GD, MRI and the injection techniques.

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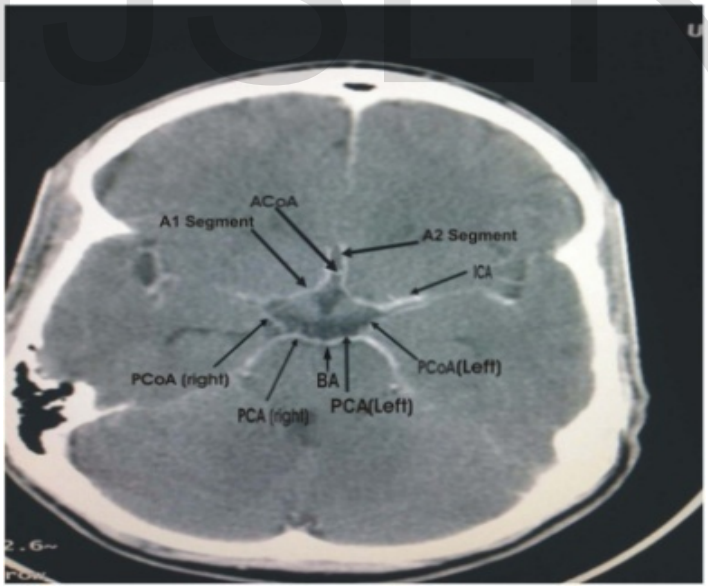


Plate 1: Axial CECT scan image of the brain demonstrating the classical or complete pattern (CP) of the circle of Willis as shown by the arrows