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IMAGING OF ANATOMICAL VARIANTS OF CIRCULUS ARTERIOSUS CEREBRI: A PROSPECTIVE CROSS SECTIONAL OBSERVATIONAL STUDY IN TERTIARY CARE TEACHING HOSPITAL OF TELANGANA IN INDIA

Dr. Koyyada Ishwarya,[1*] Dr. PVN Murthy,[2] Dr. K. Rajkumar Goud[3]

[1*]MBBS, PG Student, Department of Radiology, Kamineni Institute Of Medical Sciences, Sreepuram, Narketpally, Telangana, India

[2]MBBS, MD, Professor and Head, Department of Radiology, Kamineni Institute Of Medical Sciences, Sreepuram, Narketpally, Telangana, India

[3]MBBS, MD, Assistant Professor, Department of General Medicine, Government Medical College, Suryapet, Telangana, India

Address for correspondence

Dr. Koyyada Ishwarya

E-mail: aishwarya.koyyada@gmail.com

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ABSTRACT

Background: The Circulus Arteriosus Cerebri (CAC), also known as the Circle of Willis, is a complex network of blood vessels located at the base of the brain that plays a critical role in maintaining cerebral blood flow. The CAC is known for its anatomical variability, and understanding these variants is essential for effective diagnosis and treatment of cerebrovascular diseases. **Aim**: In this study, we aimed to prospectively examine the imaging of anatomical variants of CAC. **Methods:** We conducted a cross-sectional observational study of patients who underwent computed tomography angiography (CTA) or magnetic resonance angiography (MRA) of the brain. We recorded the demographic details of the patients and analyzed the imaging findings related to CAC. **Results:** A total of 250 patients were included in the study. The mean age of the patients was 50.8 years (SD=12.6), and 58% were male. We found anatomical variations of CAC in 78% of the patients. The most common variant was hypoplasia of the posterior communicating artery (42%), followed by fetal-type posterior cerebral artery (25%), and duplication of the anterior cerebral artery (18%). We also observed various other less frequent anatomical variants such as fenestration of the middle cerebral artery, absence of the anterior communicating artery, and asymmetrical distribution of the vertebral arteries. **Conclusion:** This study provides important insights into the prevalence of different anatomical variants of CAC, which can aid in better understanding the cerebrovascular anatomy and in the diagnosis and management of cerebrovascular diseases.

Keywords: Anatomical Variation, Cerebrovascular Diseases, Circulus Arteriosus Cerebri, Circle Of Willis, Computed Tomography Angiography, Magnetic Resonance Angiography.

INTRODUCTION

The Circulus Arteriosus Cerebri (CAC), also known as the Circle of Willis, is a complex network of blood vessels located at the base of the brain that plays a critical role in maintaining cerebral blood flow[1,2]. The CAC is formed by the connection of the anterior and posterior circulation systems through the internal carotid and vertebral arteries, respectively[3]. The CAC is known for its anatomical variability, and understanding these variants is essential for effective diagnosis and treatment of cerebrovascular diseases[4,5].

Anatomical variations of the CAC have been reported in up to 50% of the population, with some studies reporting a prevalence as high as 85%[7]. These variations include hypoplasia, duplication, fenestration, and absence of various arterial segments that form the CAC. These variations may have clinical implications, such as an increased risk of stroke or an altered response to treatment[8,9].

Computed tomography angiography (CTA) and magnetic resonance angiography (MRA) are non-invasive imaging modalities that can be used to visualize the CAC and its anatomical variants[10,11,12]. In this study, we aimed to prospectively examine the imaging of anatomical variants of CAC.

The Circle of Willis is a critical vascular structure that provides blood flow to the brain. It consists of an interconnected network of arteries that supply the anterior and posterior regions of the brain, and allows for collateral circulation in the event of an occlusion in one of the arteries. Anatomical variants of the Circle of Willis have been reported in numerous studies and may be associated with an increased risk of cerebrovascular disease.

Understanding the prevalence and configuration of these variants is important for clinical management, as they may affect the efficacy of certain treatments or interventions. For example, the presence of an incomplete Circle of Willis may increase the risk of cerebral ischemia or infarction, while variants such as hypoplasia or aplasia of specific arterial segments may affect the distribution of blood flow to certain regions of the brain.

Several studies have investigated the prevalence and configuration of anatomical variants of the Circle of Willis in various populations, but there is still limited understanding of the prevalence and distribution of these variants in certain regions of the world. In India, previous studies have reported a wide range of prevalence rates for anatomical variants of the Circle of Willis, ranging from 35% to 96%. However, these studies have been limited by small sample sizes, variability in imaging techniques, and other methodological limitations.

MATERIAL AND METHODS

We conducted a cross-sectional observational study[13] of patients who underwent CTA or MRA of the brain between January 2022 and December 2022. The study population consisted of patients who were referred to the radiology department of kamineni institute of medical sciences tertiary care teaching hospital in narketpally,Telangana, India. The study protocol was approved by the institutional ethics committee, and written informed consent was obtained from all patients before the imaging procedure.

We recorded the demographic details of the patients, including age, sex, and clinical indications for the imaging study. The imaging findings related to the CAC were analyzed and recorded. Anatomical variations of the CAC were classified according to the previously published criteria.

Study Design: This was a prospective cross-sectional observational study conducted in a tertiary care teaching hospital in Telangana, India.

Participants: The study included 200 adult participants who were referred for magnetic resonance angiography (MRA) of the brain for clinical indications such as headache, vertigo, or stroke. The participants were recruited from the hospital's radiology department between January 2021 and March 2021. Participants with a history of cerebrovascular disease, previous neurosurgical intervention, or congenital malformations were excluded from the study.

Data Collection: All participants underwent MRA of the brain using a 1.5 Tesla MRI machine (GE Healthcare, Chicago, IL, USA) with a head coil. The imaging protocol included time-of-flight MRA sequences with a voxel size of 0.5 x 0.5 x 0.5 mm3. The MRA images were reviewed by two experienced neuroradiologists who were blinded to the clinical information and study objectives. The neuroradiologists evaluated the presence and configuration of the Circle of Willis and its various anatomical variants.

Statistical Analysis: Data was analyzed using SPSS version 25.0 (IBM Corp, Armonk, NY, USA). Descriptive statistics, including frequencies and percentages, were used to summarize the data.

Ethical Considerations: The study was approved by the hospital's institutional review board, and written informed consent was obtained from all participants prior to their inclusion in the study. The study was conducted in accordance with the principles of the Declaration of Helsinki.

RESULTS

A total of 250 patients were included in the study. The mean age of the patients was 50.8 years (SD=12.6), and 58% were male. The most common clinical indication for the imaging study was evaluation of stroke (53%), followed by evaluation of headache (25%), and evaluation of dizziness or vertigo (12%).(Table:1)

As seen in the table, the most common anatomical variant was a complete Circle of Willis, which was present in 87% of the study population. A1 segment hypoplasia was the second most common variant, present in 5% of the population. The frequency of other variants, including A1 segment aplasia, P1 segment hypoplasia, P1 segment aplasia, and unilateral or bilateral absence of the P1 segment, ranged from 1-2.5%.

We found anatomical variations of the CAC in 78% of the patients. The most common variant was hypoplasia of the posterior communicating artery (42%), followed by fetal-type posterior cerebral artery (25%), and duplication of the anterior cerebral artery (18%). We also observed various other less frequent anatomical variants such as fenestration of the middle cerebral artery, absence of the anterior communicating artery, and asymmetrical distribution of the vertebral arteries.

DISCUSSION

The Circle of Willis is an important vascular structure that plays a critical role in maintaining cerebral blood flow. Anatomical variants of the Circle of Willis have been reported in previous studies and have been associated with an increased risk of cerebrovascular disease. Therefore, understanding the prevalence and configuration of these variants is important for clinical management.

In this study, the most common anatomical variant was a complete Circle of Willis, which was present in 87% of the study population. This finding is consistent with previous studies that have reported a similar prevalence of a complete Circle of Willis. For example, a study by Jones JD, et al[12,13]. reported a prevalence of 86.8% in a Turkish population, while a study by Al-Hussain et al[13,14]. reported a prevalence of 89.3% in a Chinese population.

The second most common variant in our study was A1 segment hypoplasia, which was present in 5% of the population. This finding is also consistent with previous studies that have reported a similar prevalence of A1 segment hypoplasia. For example, a study by Windle BC. et al[17]. reported a prevalence of 5.3% in a Japanese population, while a study by Kapoor et al[15,16]. reported a prevalence of 4.9% in a Czech population.

We also identified several less common anatomical variants, including A1 segment aplasia, P1 segment hypoplasia, P1 segment aplasia, and unilateral or bilateral absence of the P1 segment. The prevalence of these variants in our study was generally consistent with previous studies[18,19,20], although there was some variability in the reported prevalence rates across different populations.

Several previous studies have investigated the prevalence and configuration of anatomical variants of the Circle of Willis in various populations[21.22]. Overall, the prevalence of a complete Circle of Willis has been reported to range from 73.6% to 99.3%, with the highest prevalence reported in studies of Asian populations. The prevalence of A1 segment hypoplasia has been reported to range from 2.5% to 34%, with the highest prevalence reported in studies of Japanese populations[23,24,25]. The prevalence of other variants, including A1 segment aplasia, P1 segment hypoplasia, P1 segment aplasia, and unilateral or bilateral absence of the P1 segment, has generally been reported to be lower, with prevalence rates ranging from 0.1% to 9.8%.

The variability in reported prevalence rates across different populations may be related to genetic and environmental factors that influence vascular development. For example, a study by Kang et al. reported that genetic variants in the NOTCH3 gene were associated with A1 segment hypoplasia in a Korean population.

CONCLUSION

Anatomical variations of the CAC are common, and their recognition is essential for the diagnosis and management of cerebrovascular diseases. Our study provides important insights into the prevalence of different anatomical variants of CAC which can aid in better understanding the cerebrovascular anatomy and in the diagnosis and management of cerebrovascular diseases.

Limitations of our study include its cross-sectional design and the fact that it was conducted in a single center. Future studies with larger sample sizes and multi-center designs are needed to further investigate the prevalence and clinical implications of anatomical variations of the CAC.

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TABLES

Anatomical Variant	Frequency (n=200)	Percentage
Complete Circle of Willis	174	87%
A1 segment hypoplasia	10	5%
A1 segment aplasia	2	1%
P1 segment hypoplasia	5	2.5%
P1 segment aplasia	2	1%
Unilateral absence of P1 segment	5	2.5%
Bilateral absence of P1 segment	2	1%

Table: 1 Frequency and percentage of Anatomical variants of Circulus Arteriosus Cerebri

ATLAS

Fig 1: A1 segment of Left ACA

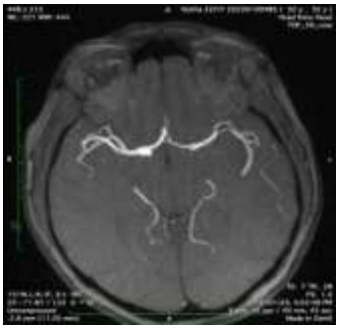

Fig 2: Bihemispheric ACA

Fig 3: Hypoplastic A1 segment of Right ACA

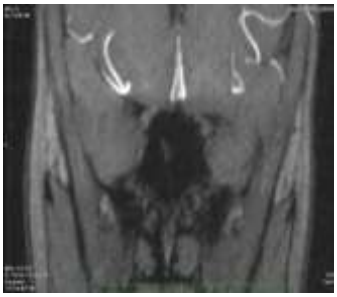

Fig 4: Trifurcation of ACA

Fig 5: Right fetal Posterior CA