Chattagram Maa-O-Shishu Hospital Medical College Journal
Volume 23, Issue 2, July 2024

Original Article

Magnetic Resonance Angiography Determined Sex-Related Variations in Configuration of Entire Circle of Willis in Bengali Population of Chattogram Division

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Date of Submission □: □17.04.2024
Date of Acceptance □: □10.05.2024

www.banglajol.info/index.php/CMOSHMCJ

Abstract

Background: *Magnetic Resonance Angiography (MRA) is a group of techniques based on Magnetic Resonance Imaging (MRI) for imaging of blood vessels. It's the most widely used method for detecting the morphology of Circle of Willis (COW). By using the 3D-TOF-MRA the present study was aimed to evaluate the anatomical variations in the Circle of Willis between male and female in Bengali population of Chattogram division.*

Materials and methods: *This cross-sectional observational study was conducted in the Department of Anatomy, Chittagong Medical College, Chattogram, upon 60 study subjects (29 were male & 31 were female) by dividing them intotwo groups (≤40 years and >40 years of age). For statistical analysis unpaired student's t-test was done and p-value was considered significant if it was <0.05 at 95% level of confidence.*

Results: *The participant's age range was between 02 -76 years with a mean ± SD age of 35.20±18.25 years. The entire Circle of Willis (COW) variations were evaluated by 3D TOF MRA between male and female. The most common configuration in both sexes was partially complete Circle of Willis (COW). On comparing the prevalence of individual configuration of COW among the gender, no significant difference was observed.*

Conclusion: *Results of the present study provides some baseline data upon which further studies can be performed by other investigators in this field. These findings might also be helpful during the surgery at the skull base.*

Key words: Bengali; Circle of Willis; 3D-TOF-MRA.

INTRODUCTION

At the base of the brain is an anastomotic artery network known as the Circle of Willis (COW).[1]It connects the anterior and posterior circulation by uniting the internal carotid and vertebrobasilar systems to maintain an adequate cerebral perfusion.[2] It is formed by thepre-communicating segment of the right and left anteriorcerebral arteries that is joined by the anterior communicating artery and pre-communicating segments of the right and left posterior cerebral arteries that are arise from the basilar artery and are connected to their corresponding internal carotid arteries via the two-posterior communicating arteries[3].

Constant and regular blood supply to the brain is primarily provided by the Circle of Willis (COW), which serves to protect the brain from ischemia.[4] Moreover, its ability to redistribute blood flow depends upon its morphology.[5] The collateral potential of the COW is believed to be dependent on the presence and size of its component vessels, which vary in calibre, being often partially hypoplastic, sometimes even absent.[6]

Considerable anatomical variations present inthe arteries of COW in their formation, development and size. Recognition of these variations in Circle of Willis (COW) is important to avoid confusion of the anomalies with aneurysms, evaluate collateral pathways in the intracerebral circulation, and enhance pre-operative planning in patients undergoing surgery at the skull base.[7]

With time and advancement in technologies, the definition of a normal COW has been made more precise.[8] It is considered as complete when all components of the anterior and posterior parts of the circle are visible, continuous and demonstrates a diameter of at least 0.8 mm. An incomplete configuration means that neither the anterior nor posterior part of the circle (A hypoplastic or absent vessel) form a complete circle. A partially complete configuration means either anterior or posterior parts of the arterial circle forms a complete circle.[9]

Previous research on the average artery widths of COW was done on autopsied corpses rather than living subjects, which did not accurately represent the typical state of COW.[10] Instead of using anatomical methods of inspection, the advent of imaging diagnostic techniques, such as CTA, Magnetic Resonance Angiography (MRA) allows for a complete, accurate and precise morphometric assessment of the blood arteries.[11]Among these, MRA (Magnetic Resonance Angiography) is a non-invasive, sensitive imaging technique that can be used to identify the morphology of Circle of Willis (COW).[12]

Using this technique, numerous studies have been conducted and reported different anatomical variations of COW in worldwide.[13]In addition, it has been observed that a wide range of variables, such as race and ethnicity, affect the occurrence of certain COW variants.[14]The aim of this study was to determine the different types of variations in the entire Circle of Willis between male and female in Bengali population of Chattogram Division.

MATERIALS AND METHODS

This cross-sectional observational study with some analytical component was carried out in the Department of Anatomy of Chittagong Medical College, Chattogram during the period from September 2021 to August 2022. After getting approval from the ethical review committee of Chittagong Medical College, study subjects were selected according to enrollment criteria. Data were collected from the Radiology and Imaging unit of Epic health care, Max Hospital and Diagnostic Ltd, Chevron Laboratory Ltd, Chattogram- who have undergone MRI of the brain with MRA for different clinical reasons. Informed written consent was taken from the patient after giving detailed information about using their MRA images in the study. The study population were 60 in number (29 were male and 31 were female) by dividing them into two groups (≤40 years and >40 years of age). Age was recorded according to NID/birth certificate. Subjects having any history of head and neck surgeries, pathological lesions at the base of the brain, had pace makers, ferromagnetic intracranial aneurysm clips or other metallic implants and tribal people were excluded. The 3D-TOF-MRA of the circle of were obtained witha 3-tesla MRA scanner (Siemens, Germany, Philips, Netherlands). Imaging parameters are repetition time (TR): 20-24ms, echo time (TE): 3.4-3.6ms,18 o flip angle: 18-20 degree, field of view: 200-220, axial slice: 48-52/slab, slice thickness: 0.4-0.6 mm, total imaging time: approximately 4min 1sec - 5min 3 sec. The variations in the entire Circle of Willis (COW) – complete COW (Figure 4) incomplete COW (Figure 5) and partially complete COW (Figure 6) was observed from all the DVDs separately by an expert Radiologist of Chittagong Medical College Hospital (CMCH). The anterior and posterior part of the Circle of Willis (COW) were evaluated separately for variations and the measurement of diameter of the component vessels of the Circle of Willis were also taken by image analyzing softwire.

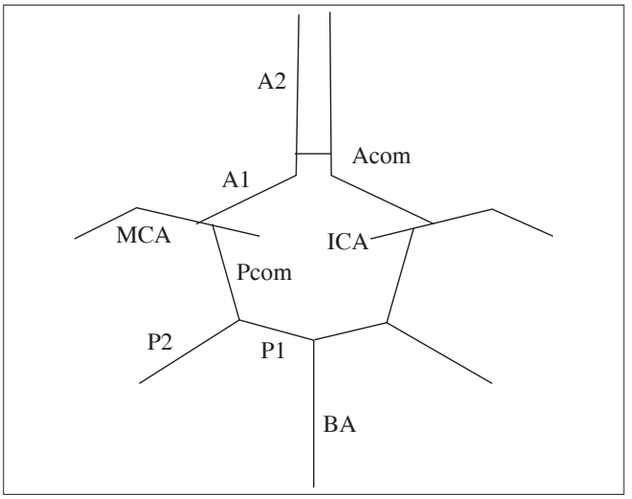

Figure1 Schematic diagram of the vessels that form the complete Circle of Willis (COW)

Anterior variation of COW:

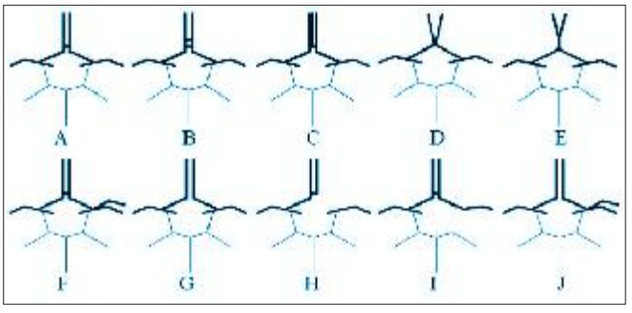

Figure 2 Schematic diagram of anatomical variations in the anterior part ofthe COW

A. A single anterior communicating artery. The ICA bifurcates into the pre communicating segment of the anterior cerebral artery and the MCA. B. Two or more AComAs. C. Medial artery of the corpus callosumarises from the AComA. D. Fusion of the ACAs over a short distance. E.ACA form a

common trunk and split distally into two post communicating segments. F. MCA originates from the ICA as two separate trunks. G. Hypoplasia or absence of an anterior communication. H. One pre communicating segment of an ACA is hypoplastic or absent, the other pre communicating segment gives rise to both post. communicating segments of the ACAs. I. Hypoplasia or absence of an ICA. The contralateral pre communicating segment of the ACA gives rise to both post communicating segments and supplies retrograde flow to the ipsilateral pre communicating segment, which, in turn, gives rise to the ipsilateral MCA. J. Hypoplasia or absence of an anterior communication. The MCA arises as two separatetrunks.

Posterior variation of COW:

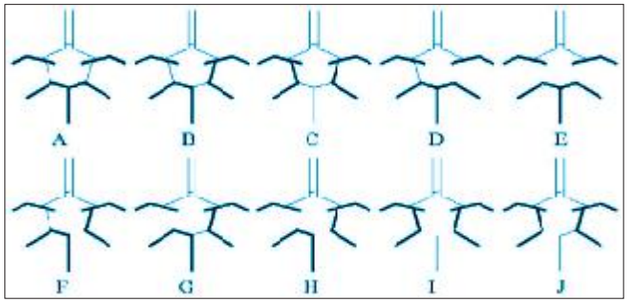

Figure 3 Schematic diagrams of anatomical variations of the posterior part of the COW.

A. Bilateral Pcom Asare present. B. PCA originate spred ominantly from the ICA. This variant is known as unilateral fetal type posterior cerebral artery, the PComA on the other side is patent. C. Bilateral fetal type posterior cerebral arteries with both pre communicating segments of the PCA spatent. D. Unilateral PComA present. E. Hypoplasia or absence of both PComAs and isolation of the anterior and posterior part of the circleat this level. F. Unilateral fetal type posterior cerebral artery and hypoplasiaor absence of the pre communicating segment of the posterior cerebralartery. G. Unilateral fetal type posterior cerebral artery and hypoplasia or absence of the contral ateral PComA. H. Unilateral fetal type posterior cerebralartery and hypoplasia or absence of both pre communicating segment of the posterior cerebral artery and the PComA. I. Bilateral fetaltype posterior cerebral arteries with hypoplasia or absence of both pre communicating segment sof the PCAs. J. Bilateral fetal type posterior cerebral arteries with hypoplasia or absence of the pre communicating segment of either PCA.

Figure 4 MR angiogram of a Complete Circle of Willis (Type-A)

Figure 5 MR angiogram of an incomplete Circle of Willis showing absence of an anterior communicating artery termed as anterior variation (Type - G) and absence of left posterior communicating artery termed as posterior variation (Type - D), marked by red arrows

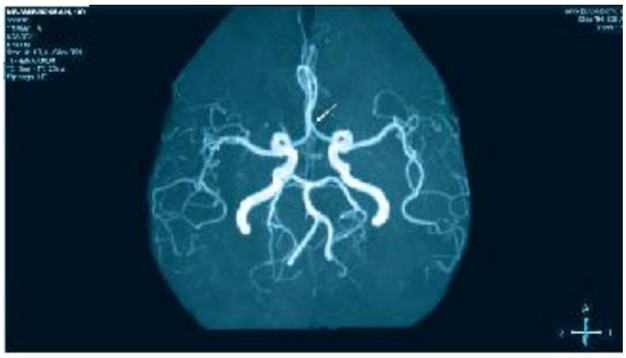

Figure 6 MR angiogram of a partially complete Circle of Willis showing absence of an anterior communicating artery termed as anterior variation (Type - G) marked by red arrow

All collected data were entered into computer and analyzed by SPSS (Statistical Package for Social Science) version-25 software programme. The participants were divided into two groups (Male and Female). Different types of variations in the entire Circle of Willis (COW) - complete COW, incomplete COW and partially complete COW were compared between these two sex groups of study subjects by using Chi square test. The result was considered as significant if the p value is <0.05 at 95% level of significance.

RESULTS

A total of 60 respondents were enrolled in the study. The participant's age ranges were between 02-76 yearswith a mean ± SD age of 35.20±18.25 years. The participants were divided into two groups (Male and Female). There were 29 (48.3%) males and 31 (51.7%) females. The mean age ± SD of male was 37.21±18.395 years and mean age of the female was 33.22±18.218 years (Table I). Figure 7 shows the distribution of variations in the entire Circle of Willis among the study population. Where, among the 60 study subjects, 23 (39%) subjects have a complete COW, 29 (48%) have a partial COW and 8 (13%) have an incomplete COW.

Table II shows the distribution of the different types of variations in the entire Circle of Willis (COW) between male and female. In case of gender of study subjects, a complete COW was observed in 11 (37.9%) males and 12 (38.7%) females. A partially complete COW was observed in 14 (48.3%) males and 15 (48.4%) females and an incomplete COW was found in 4 (13.8%) males and 4 (12.9%) females. Chi squared test was performed and no significant difference was observed.

Table I Distribution of the study subjects according to gender (n=60)

Gender	Age (in years)		
	Age	Number	Mean ± S.D
Male	04-74	29	37.21±18.395
Female	02-76	31	33.22±18.218
Total	02-76	60	35.20±18.253

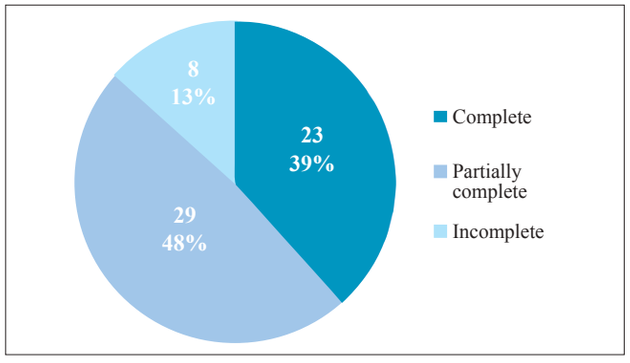

Figure 7 Distributionof variations in the entire Circle of Willis among the study population (n=60)

Table II Distribution of different types of variations in the entire Circle of Willis between male and female (n=60)

Gender	Anatomical Morphology of COW		
	Complete	Partially complete	Incomplete
Male	11 (37.9%)	14 (48.3%)	4 (13.8%)
Female	12 (38.7%)	15 (48.4%)	4 (12.9%)
Total	23 (39%)	29 (48%)	8 (13%)
p value	0.581	0.599	0.608

DISCUSSION

In case of gender wise distribution among the study subjects, a complete Circle of Willis (COW) was observed in 11 (37.9%) males and 12 (38.7%) females. A partially complete COW was observed in 14 (48.3%) males and 15 (48.4%) in females and an incomplete COW was found in 4 (13.8%) males and 4 (12.9%) in females. The most common configuration in both sexes was partially complete COW. On comparing the prevalence of individual configurations of COW among the genders using a Chi-squared test, no significant difference was observed. However, entirely complete COW was observed 38.7% in females and 37.9% in male and a partially complete COW was 48.4% and 48.3% respectively in female and male. While males showed a slightly higher prevalence of incomplete COW than female (13.8% vs 12.9%). This finding was similar to the study of Zaki et al. conducted in Egypt, where females had a higher prevalence of entirely complete (33.3%vs 25%) and partially complete configuration of COW (38.9% vs 37.5%) while males had a higher prevalence of incomplete configuration (37.5% vs 27.8%) of COW.[15]

But in another study conducted by Chen H W et al. in Taiwan among 507 participants, the observation is partially agreed with this study where prevalence of complete COW was more common in females (26.69% vs 15.35%) and prevalence of incomplete COW was more common among male (19.92% vs 15.41%), which is similar to this study, but the prevalence of partially complete configuration was more in male as compared to female (64.73% vs 57.89%).[16] This dissimilarity may be due to the sample size variation. Also, variations in geographic location could also have caused such changes.

LIMITATIONS

The study has certain limitations such as only three centers study, small sample size and short duration of period.

CONCLUSION

In this study, the variations in the entire Circle of Willis (COW) – complete COW, incomplete COW and partially complete COW was observed between male and female. Variations in the anterior and posterior part of the COW were also observed among the study subjects but that was not statistically significant. A detailed knowledge of the vascular variants with diameters of the vessels of COW is useful to surgeons in planning their shunt operations, choice of the patients and also keeps away iatrogenic vascular traumas during surgeries. Moreover, the knowledge obtained from this study may also useful to anatomists and sonologists in enhancing their knowledge in teaching and investigative procedures.

RECOMMENDATION

Studies with larger sample size and multicenter based study is to be recommended.

ACKNOWLEDGEMENT

Authors express their gratitude to our honorable supervisor & teachers for guidance.

DISCLOSURE

All the authors declared no competing interests.

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