Megnetic Ressonance Angiography Based Comparison of Age-Related Variations in Vascular Diameter of Circle of Willis in Bengali Population of Chattogram Division

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Abstract

Background: Magnetic Resonance Angiography (MRA) is a non-invasive and non-radiation dependent 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 determine whether there is any differenceof COW vessels diameters between two specified age groups 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 and 31 were female) by dividing them into two 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 mean vessel diameters of vessels were compared between two age groups (≤40 years and >40 years of age) and majority of vessels showed statistically nonsignificant differences between two age groups except the diameter of Basilar Artery (BA) which shows significantly larger (p=0.027) in subjects >40 years of age.

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.

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Introduction

The Circleof Willis (COW) is a circulatory anastomosis atthe base of the brain uniting the internal carotid and the vertebrobasilar system.[1] carotid arteries supply the anterior circulation while the basilar artery supply the posterior circulation.[2] It is formed by the pre-communicating segment of the right and left anterior cerebral 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.[3,4]

It is a potential collateral pathway of blood flow in cases of reduced cerebral perfusion.[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]

COW is called 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.[7]

Earlier, studies dedicated to analysis of mean diameters of the arteries of COW were conducted on cadaver by autopsy rather than live individuals which did not reflect the normal status of COW.[8] The development of imaging diagnostic methods, such as Magnetic Resonance Angiography (MRA) allows detailed, precise and accurate morphometric examination of the blood vessels rather than anatomical methods of examination.[9] It has a high level of sensitivity as well as specificity

as compared to other techniques.[10] Using this technique, numerous studies have been conductedin worldwide. Some radiological studies previously conducted, that dealt with the measurement of the diameter of arteries of the COW, showed age-related differences in the vessel diameter while others found noage related differences.[11] The aim of this study was to determine the normal luminal diameters of the arteries of COW and to compare the diameters of the arteries of COW between two specified age groups 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. 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 underwent 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 populations were 60 in number. Age was recorded according to NID/birth certificate. Subjects having any history of head & neck surgeries, pathological lesions at the base of the brain, had pacemakers, ferromagnetic intracranial aneurysm clips or other metallic implants and tribal people were excluded. The 3D-TOF-MRA of the circle of were obtained with a 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: 18-20degree, field of view: 200-220, axial slice: 48-52/slab, slice thickness: 0.4-0.6mm, total imaging time: approximately 4min 1sec - 5min 3 sec. The measurements were done with the image analysis software with the MRI machine.Vessels which were visualized as continuous segments of at least o.8 mm diameter were considered as present. Those smaller than 0.8 mm indiameter were considered as hypoplastic. The anterior and posterior part of the COW were evaluated separately by an expert radiologist of CMCH. Vessels which were visualized as non-continuous segments were considered as absent. Absent vessel diameters were regarded as zero when determining mean vessel diameter. The diameters of the vessels were measured as follows; Basilar Artery (BA) just before it gives branch to posterior cerebral arteries (Figure 1) pre communicating segment of posterior cerebral arteries (P1) (Figure 2) cavernous segment of Internal Carotid Arteries (ICA) (Figure 3), pre communicating segment of anterior cerebral arteries (A1) (Figure 4). The diameters of vessels were expressed in millimeter (mm).

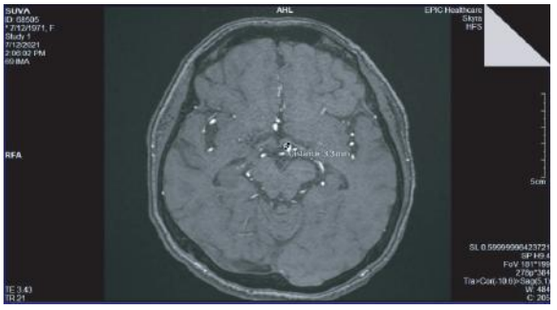

Figure 1 MR angiogram of a Circle of Willis showing diameter of basilar artery

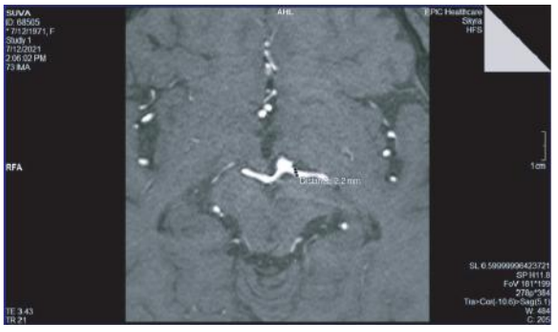

Figure 2 MR angiogram of a Circle of Willis showing diameter of left posterior cerebral artery

Figure 3 MR angiogram of a Circle of Willis showing diameter of left internal carotid artery

Figure 4 MR angiogram of a Circle of Willis showing diameter of right and left anterior cerebral artery

All collected data were entered into computer and analyzed by SPSS (Statistical Package for Social Science) version-25 software program. The participants were divided into two groups (≤40 years of age and >40 years of age). Mean diameters of the arteries were compared between these two age groups ofstudy subjects by using unpaired t-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 (≤40 years of age and >40 years of age). There were 38 (63.3%) study subjects in ≤ 40 age group, while the remaining 22 (36.7%) subjects were in >40 years age group. Table-I shows the comparison of the diameters of vessels of COW between the participants of ≤ 40 years of age and >40 years of age group. On comparing the mean vessels diameters by using unpaired student's t-test according to age group,mean diameter of basilar artery was significantly larger (p=0.027) in subjects of >40 years of age. The comparison of the diameters of pre communicating segment of Posterior Cerebral Artery (PCA-P1), Internal Carotid Artery (ICA) pre communicating segment of Anterior Cerebral Artery (ACA-A1) and Anterior Communicating artery (AComA) between two age groups showed no significant differences.

Table I Comparison of the diameters of vessels of COW between participants of ≤40 years of age and >40 years of age groups

Vessel	Mean vessel diameter (mm)				p-value
	≤ 40 years		40 years		
	Mean	SD	Mean	SD	
ICA					
Right	4.34	0.51	4.26	0.59	0.595
Left	4.33	0.52	4.22	0.48	0.405
Basilar (BA)	3.01	0.23	3.27	0.31	*0.027
ACA-A1					
Right	2.09	0.3	1.96	0.28	0.1
Left	1.98	0.24	1.9	0.22	0.22
PCA-P1					
Right	2.03	0.16	2.09	0.29	0.35
Left	1.99	0.21	2.06	0.21	0.22
AComA	1.13	0.14	1.11	0.12	0.69

{*= Significant (p <0.05), ICA= Internal Carotid Artery, BA= Basilar Artery, ACA-A1= Pre communicating segment of Anterior Cerebral Artery, PCA-P1= Precommunicating segment of Posterior Cerebral Artery, AComA= Anterior Communicating Artery}.

Discussion

In the present study, mean diameter of basilar artery was found significantly larger (p=0.027) among participants >40 years of age (3.27 ± 0.31 mm) as compared to patients ≤40 years of age (3.01± 0.23 mm).

Similar findings were observed in the study conducted by Jeton et al and Maaly & Ismail. Jeton S et al conducted a study among 513 participants in Kosova where Basilar Artery (BA) was significantly larger in diameter (3.34 ± 0.2 mm) among individuals >40 years of age than individuals <40 years of age (3.21 ± 0.33mm) which was statistically significant p= 0.0001.[4] Similar finding also observed by Maaly and Ismail among 180 participants in Egypt where diameter of basilar artery was larger (3.09± 0.12mm) in participants ≥40 years of age than participants<40 years of age (2.91± 0.14mm) which was statistically significant (p<0.05).[12]

But Chen et al in Taiwan conducted a study among 507 individuals and found that the diameter of BA in >40 years age group was in 2.9±0.45mmand in <40 years age group was in 2.8±0.42 mm. But this was statistically not significant with p> 0.05.[10] This finding is slightly

dissimilar with the findings of the current study. This dissimilarly may be due to their larger sample size.

In the present study the diameters of both sided ICAs, ACA-A1 and PCA- P1 in both age group have shown some difference but the differences were not statistically significant. The diameter of AComA was also measured in this study in both age group and have shown little variation but was not statistically significant p = 0.69. The study by Zaki et al found that the diameters of both sided ICAs, PCA-P1 and in AComA in both age group have shown some difference but was not statistically significant. They also found that in <40 years age group the mean diameter of right ACA-A1 was larger (2.4 ± 0.6mm) as compared with the ≥40 years age group (2.0 ± 0.4mm) and this was statistically significant ($p<0.001$)[13]. These finding is slightly dissimilarwith the findings of current study. This dissimilarly may be due to their larger sample size.

Limitation

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

Conclusion

In this study, when comparing the mean vessel diameters by using unpaired student's t-test, basilar artery was found to be larger in diameter in the age group >40 years and that was statistically significant (p = 0.027). 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 radiologists in enhancing their knowledge in teaching and investigative procedures.

Recommendation

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

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Contribution of authors

JH-Concept, design, data collection, data analysis, manuscript writing and final approval of the draft.

SB-Design, manuscript writing and final approval of the draft.

MA-Conception, design, manuscript writing and final approval.

SB-Data collection, interpretation of data and critical revision.

IUR-Data collection, manuscript writing and final approval.

Disclosure

All the authors declared no competing interests.

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