Original Article

ID: JCDR/2012/4103:2229

Anatomy Section

Length of the Anterior Cerebral Artery (ACA) on MRI Angiograms

NAVITA AGGARWAL, MOLLY. M. PAUL , MADHUMITA MUKHERJEE, J.N. TOPPO, MANJOT KAUR, GAURAV GOEL

ABSTRACT

Magnetic Resonance Imaging, by far, has been found to be the most sensitive and non-invasive method for detecting angiographic images on the circle of Willis. The length of the vessels which form part of the circle of Willis is important for neurosurgeons while they perform various neurological procedures. It also helps the radiologists in interpreting the angiographic images in a better way. The length of the vessel also affects the haemodynamics of the vessel, thus affecting the major role of the circulus arteriosus as an anastomotic channel. Though many studies have been conducted on cadavers to measure the length of various cerebral vessels, not much work has been done on the length of the vessels by using modern techniques like MRI. The vessel length in the circle of Willis on MRI has not been reported, especially in this region of north India. This study was conducted on 120 normal angiographs which were taken by magnetic resonance angiographic techniques. In the results which were obtained in the present study, the length of the vessel was found to be higher on the left side. The range of the length on the right side was 10.4mm - 27.54mm, the mean length being 15.78mm ± 3.71mm, whereas on the left side, the range of the length was 10.6mm - 31.96mm and the mean length was 17.37mm ± 4.84mm . The present study gave the length of the anterior cerebral artery according to the side. In view of this, the length which is presented here may provide reference values which are specific to the three dimensional time of flight MRI angiography and it may be of value in the investigation of other pathologic features of the circle of Willis.

Key Words: Anterior Cerebral Artery, Length, Angiograms, MRI

INTRODUCTION

The Anterior Cerebral Artery (ACA) on each side of the circle of Willis, is a branch of the internal carotid artery. The two ACAs complete the circle of Willis anteriorly through an anastomosis between them – the anterior communicating artery (A Com A.). The surgical nomenclature divides the vessels into three parts; A1 – from the termination of the internal carotid artery to the junction with the anterior communicating artery; A2 – from the junction with the anterior communicating artery to the origin of the callosomarginal artery; and A3 – distal to the origin of the callosomarginal artery. The A1 segment is also known as the pre-communicating part of the anterior cerebral artery [1].

It is well known that MRI angiography is a sensitive and non-invasive modality which is suitable for detecting the anatomy of the circle of Willis. MRI angiography is said to have 100% sensitivity and 100% specificity for the anterior, middle and the posterior cerebral arteries. This modality is useful for finding a standard of reference for research on the anterior cerebral artery – the focus of the present study. The aim of the present study was to find out the variations in the length of the anterior cerebral artery in relation to the side in the living, on MRI angiograms.

MATERIAL AND METHODS

This study was conducted on 120 normal angiograms of adult patients who underwent the three dimensional time of flight Magnetic Resonance Angiography of the circle of Willis at 1.5 Tesla field strength scanners in the Department of Radiodiagnosis and Imaging at Christian Medical College, Ludhiana and at Adesh Institute of Medical Sciences And Research, Bathinda, India.

All the angiograms were evaluated at the Radiology Department's workstation, on its maximum intensity projections as well as its source images. The A1 segment of the anterior cerebral artery, which is one of the components of the circle of Willis, was studied for its length. The following two points were marked separately for ACA,

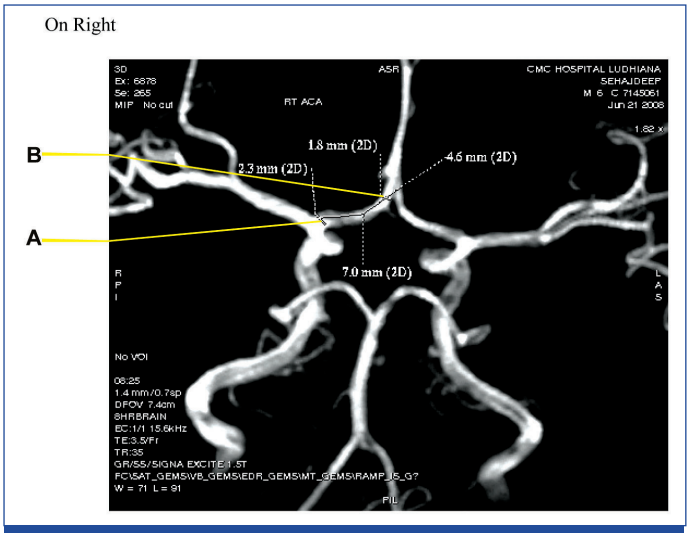
- at its origin from the internal carotid artery (taken as point 'A'),
- at the proximal part of its junction with the anterior communicating artery (taken as point 'B').

Then, the lengths of the A1 segment of the anterior cerebral artery on the right and left sides were measured between the two points (point 'A' and 'B'). Due to the course of the artery being tortuous with angulations, the length was measured in segments, which were then added and the total length was calculated.

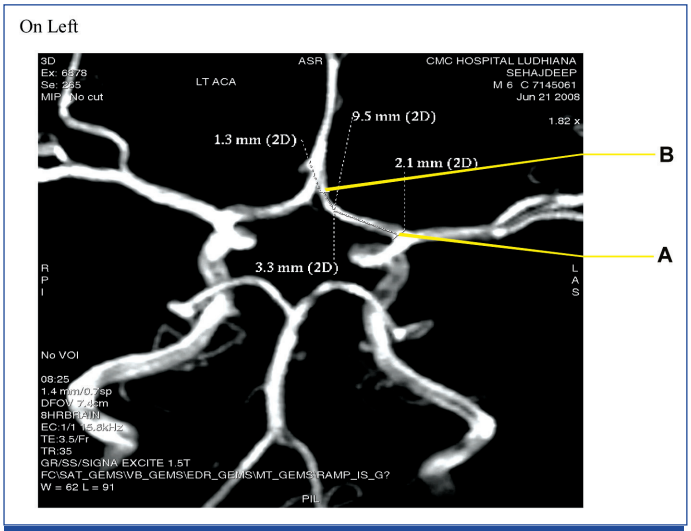
The projections which showed the anterior part of the circle of Willis with minimum overlapping were selected for taking measurements. The cases in which points 'A' and 'B' at which the measurements were to be taken were not clear, either because of overlapping in the projections or because of any other reasons, were not included. Also, the cases in which any of the projections could not make the entire course of the A_1 anterior cerebral artery clear, were not included for the study.

MRI ANGIOGRAMS

Measurements of the length of the Anterior Cerebral Artery were taken on the right and left sides on the MRI angiograms.



[Table/Fig-1]: Measurements of the length of the Anterior Cerebral Artery were taken on the right side on the MRI angiogram.



[Table/Fig-2]: Measurements of the length of the Anterior Cerebral Artery were taken on the left side on the MRI angiograms.

Right				Left					
Mean	SD	SEM	CV	Mean	SD	SEM	CV	p-value	t-value
15.78	3.71	0.52	23.5	17.37	4.84	0.68	27.9	0.07	1.85

[Table/Fig-3]: Length of anterior cerebral artery (between points 'A' and 'B') in millimeters on MRI angiograms on right and left sides in total of 120 cases.

RESULTS

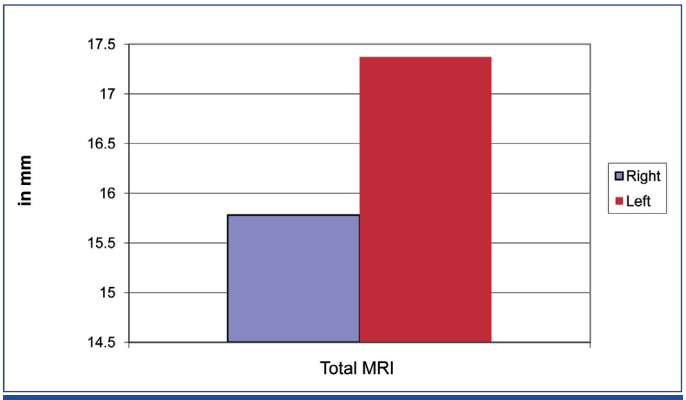
[Table/Fig-3] the length of the anterior cerebral artery (between points 'A' and 'B') in millimeters on the MRI angiograms on the right and left sides in a total of 120 cases.

On comparison of the right and the left segments, the length was found to be more on the left side than on the right side. The difference of the length on the two sides was statistically non-significant.

[Table/Fig-4] (Graph 1): Depicts the comparison of the right and left segments for the length of the anterior cerebral artery.

DISCUSSION

Various authors have measured the length of the A1 segment of the anterior cerebral artery on cadaveric brains and the values which have been given by them have been tabulated below in comparison to the values which were obtained in the present study which was conducted on MRI angiograms.



[Table/Fig-4]: depicts the comparison of Right and Left segment for length of anterior cerebral artery.

Author	Year	Length on right side	Length on left side
Murray	1964	13.2mm	12.9mm
Kamath	1981	14.7 ± 3.0mm	13.8 ± 2.7mm
Orlandini et al	1985	14.1 ± 2.7mm	13.6 ± 2.8mm
Gomes et al	1986	15.0 ± 7.6mm	15.0 ± 7.3mm
Pai et al	2005	14.6mm	14.5mm
Mandiola et al	2007	12.86 ± 1.58mm	12.6 ± 1.96mm
Present study	2008	15.78 ± 3.71mm	17.37 ± 4.84mm
Krishnamurthy A	2010	14.49 ± 0.28mm	14.22 ± 0.22mm

[Table/Fig-5]: Comparison of results in present study with observation by various authors.

Also, Saeed A et al, in 2011, by using public domain software, found the length of the A_1 segment to be12.5 + /_ 2.2 mm [9].

The lengths of the segments of each of vessels that compose the arterial pattern in the circle of Willis are also significant for the blood flow in it, besides the fact that this will determine the configuration of the system [10]. The study of the length of the vessels is important because it has been verified that the non-linearity of the flow characteristics of the vessel segments, to a great extent, is caused by their tortuosity and small length, in relation to their diameter. The non-linear effects are particularly pronounced in the condition of the pathological occlusion of the supplying vessels [11]. It has also been reported that the large asymmetries in the volume flow between the right and left sides is not necessarily caused by vascular diseases, but that they may be caused by the variation in the anatomy of the circle of Willis [12].

The data of this study can provide precise micro-anatomic information for the surgical treatment of aneurysms or vascular reconstructive procedures in the circle of Willis [5]. Also, the anatomic parameters of the anterior cerebral artery may be used to plan and design devices such as angiographic micro catheters and guides which are used in endovascular procedures [13].

An idea of the normal dimensions of this vessel may contribute greatly to the surgeons' assessment of the feasibility of 'shunt operations'. Also, it must be emphasized that a wider range of information on the size of the considered artery may be useful for a better interpretation of the angiographic images and for a deeper understanding of the cerebral pathology [4]. Thus, recognizing the variations of the anterior cerebral artery during the interpretations of cranial angiograms is extremely important [14].

Several factors can account for the variation in these results. Firstly, the selected study populations differ (the vessels in the normal

brains, as compared to the vessels in the brains with evidence of neurovascular disease). Secondly, the methods and techniques of the examination differ (anatomic dissection vs conventional contrast material enhanced angiography vs phase contrast or time of flight angiography). Thirdly, the investigators use a set of criteria to define a normal or complete circle of Willis. The specific condition of a selective patient population may also contribute to the variability.

Although the time of the flight MRI angiography has demonstrated a high sensitivity for the detection of the circle of Willis vessels, the technique does have its limitations, such as difficulties in depicting the small vessels with slow or turbulent flow. The signal intensity of blood flow within a vessel is dependent on the replenishment of fully magnetized spins as they enter the imaging section for a maximum flow effect in the time of flight MRI angiography. The sensitivity of the three dimensional time of flight MRI angiography for the detection of small communicating vessels, improves with the flow through these vessels, as the flow velocity improves the signal intensity. Non-visualization of the vessels on the time of flight MRI angiograms can be due to any slow or negligible flow within a patent vessel or due to the true absence of the vessel [15].

The present study gives the length of the anterior cerebral artery and its difference according to side and sex. In view of this, the length which has been presented here may provide reference values which are specific to the three dimensional time of flight MRI angiography and it may be of value in studies in which the three-dimensional time of flight MRI angiography is used to investigate other pathologic features of the circle of Willis.

ACKNOWLEDGEMENT

Acknowledge with deep gratitude the people in the department of Radiology and in department of Anatomy, Adesh institute of medical science and Research (AIMSR), Bathinda. for their suggestions and support rendered to me in completion of this work. My special thanks to Mr. Anil for his help with statistical compilation of the study. I would like to thank Miss. Pavitra and Mr. Ashwani, the MRI technicians for the long hours that they devoted for helping me in the data collection for this study.

REFRENCES

[1] Standring S. Development of the nervous system. In: Standring S, Ellis H, Healy JC, Johnson D, Williams A, Collins P, et al editors. Gray's Anatomy, The Anatomical Basis Of Clinical Practice. 39th ed. Elsevier Churchill Livingstone; 2005; 241-74.
[2] Murray KD. Dimensions of the circle of Willis and dynamic studies which were done by using electrical analogy. *J Neurosurg*. 1964;21:26-34.
[3] Kamath S. Observations on the length and diameter of the vessels which form the circle of Willis. *J Anat*.1981;133:419-23.
[4] Orlandini GE, Ruggiero C, Orlandini SZ, Gulisano M. Blood vessel size of the circulus arteriosus cerebri (circle of Willis). A statistical research on 100 human subjects. *Acta Anat*.1985;123:72-6.
[5] Gomes FB, Dujovny M, Umansky F, Berman SK, Diaz FG, Ausman JI. Micro-anatomy of the anterior cerebral artery. *Surg Neurol*. 1986; 26:129-41.
[6] Pai SB, Kulkarni RN, Varma RG. Micro-surgical anatomy of the anterior cerebral artery-the anterior communicating artery complex: An Indian study. *Neurology Asia*. 2005;10:21-28.
[7] Mandiola E, Alarcon E, Onate JC, Sanhueza P, Sol M, Olave E. Biometrical aspects of the anterior cerebral artery in its proximal segment (A1) and in the internal carotid artery. *Int J Morphol* 2007;25:915-18.
[8] Krishnamurthy A, Nayak SR, Bagoji IB, D'Costa S, Pai MM, Jiji PJ, et al. Morphometry of the A1 segment of the anterior cerebral artery and its clinical importance. *Clin Ter*. 2010; 161(3):231-4.
[9] Saeed A, Majid D , Behzad E, Douglas J. M, Sarah G, Hassan A. et al. A simple technique for the morphological measurement of the cerebral arterial circle variations by using public domain software (Osiris). *Anat Cell Biol*. 2011; 44(4): 324–30.
[10] Pallie, W. A study on the quantification of the circle of Willis. *Brain*.1962; 85(3): 569-78.
[11] Cieslicki K, Ciesla D. Investigations on the flow and pressure distributions in the physical model of the circle of Willis. *J Biomech*. 2005;38:2302-10.
[12] Hendrikse J, Van Raamt AF, van der Graaf Y, Mali WP, van der Grond J. Distribution of the cerebral blood flow in the circle of Willis. *Radiology*. 2005;235:184-89.
[13] Stefani MA, Schneider FL, Marrone ACH, Severino AG, Jackowski AP, Wallace MC. Anatomic variations of the anterior cerebral artery's cortical branches. *Clin Anat*. 2000;13:231-36.
[14] Uchino A, Nomiyama K, Takase Y, Kudo S. Anterior cerebral artery variations which were detected by MR angiography. *Neuroradiology*. 2006;48:647-52.
[15] Hartkamp K, Grond JV, Leeuw FE, Groot JC, Algra A, Hillen B. Circle of Willis: Morphologic variation on the three-dimensional time-of-flight MR angiograms. *Radiology*. 1998; 207:103-11.

AUTHOR(S):
1. Dr. Navita Aggarwal
2. Dr. Molly M. Paul
3. Dr. Madhumita Mukherjee
4. Dr. J.N. Toppo
5. Dr. Manjot Kaur
6. Dr. Gaurav Goel

PARTICULARS OF CONTRIBUTORS:
1. Corresponding Author,
2. (Professor) Department of Anatomy,
   Christian Medical College (CMC), Ludhiana (Punjab), India.
3. Assistant Professor(Department of Anatomy)
   Christian Medical College, Ludhiana, (Punjab) India.
4. Professor and Head
   Department of Radiodiagnosis and Imaging
   Christian Medical College, Ludhiana, (Punjab) India.
5. Associate Professor, Department of Radiology
   Adesh Institute of Medical Sciences and Research,
   Bathinda, (Punjab), India.
6. M.B.B.S

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Navita Aggarwal, M.S. (Anatomy)
(Assistant Professor) Department of Anatomy
Adesh Institute of Medical Sciences and Research,
Bathinda, (Punjab) India.
Phone: +919855424777
E-mail: navita22a@gmail.com

FINANCIAL OR OTHER COMPETING INTERESTS:
None.

Date of Submission: **Feb 03, 2012**
Date of Peer Review: **Mar 26, 2012**
Date of Acceptance: **May 05, 2012**
Date of Publishing: **Jun 22, 2012**