

# Different Anatomical Variations of circle of Willis in adult patients on magnetic resonance angiography

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## ABSTRACT

**Background:** The COW shows vast variations in different individuals. The aim of this study was to evaluate and describe the prevalence and patterns of arterial variants and the different morphological variations of the COW on MRA in adult Pakistanis.

**Aim:** To find the different anatomical variations of Circle of Willis in adult patients on magnetic resonance angiography.

**Methodology:** In this descriptive study a total of 90 patients with ages 20-90 years, were selected for the study between July 2021 till October 2021. The adult patients were referred for screening MRA brain in the Department of Radiology. The protocol selected to visualize the COW was 3D-TOF MRA.

**Results:** Data analysis demonstrates that out of total 90 patients, 51(56.7%) were males and 39(43.3%) were females. Overall, 66(79.5%) circles were complete in anatomical configuration and 24(20.5) were incomplete. The anterior circle was complete in 73(81.1%) subjects and incomplete in 17(18.9%) subjects. The posterior circle was complete in 83(92.2%) subjects and incomplete in 7(7.8%) subjects. The most common variation of COW was hypoplasia/absence of segments of Circle of Willis. ACA was the most frequent segment of Circle of Willis that was hypoplastic/absent followed by A1 segment of right ACA is absent in 6(7.2%) subjects and A1 segment of right ACA is hypoplastic in 6(7.2%) subjects.

**Conclusion:** The study concludes that mostly the COW is complete in Pakistani adults. There are variations particularly in anterior part as compared to the posterior part of the COW. The most common variants are of A1 segment of Right ACA as compared to other type of variants.

**Keywords:** Circle of Willis, 3D-TOF-MRA, Anterior circulation, Posterior circulation, Complete circle, Incomplete circle,

## INTRODUCTION

The method of the arrangement of blood vessels in the human body is extremely complicated, and the patterns of vessels on the embryonic stage are relatively diverse from those in adulthood. Multiple oddities may arise during the mutation of embryonic vessels to mature vessels. Vascular revelations are various and are non diseased in numerous patients.<sup>1,2</sup> The COW is a band of interrelated arteries existing at the core of head that replenishes blood to the brain and nearest hierarchies. It comprises of anterior cerebral, anterior communicating, internal carotid, posterior cerebral and posterior communicating arteries associated in a round shape.<sup>3,4</sup> The COW is split up into two anterior and posterior parts relying upon the blood flow to the portion of the brain. Carotid arteries and their regions play a part in the anterior circulation and the vertebra-basilar network provides to the posterior circulation.<sup>5</sup> It influences significant functions in supervision of reliable intracranial blood stream and perfusion pressure. Growing classification, difference, and extent of opening of the anatomy all impact on its objective as an origin of balanced flow.<sup>6</sup>

Components in the COW are generally missing or hypoplastic making the COW incomplete.<sup>7</sup> Researches have illustrated that these changes play fundamental part in the advancement of cerebrovascular diseases, for instance aneurysms, infarcts and further vascular abnormalities.<sup>8,9</sup> So recognition of such divergences in a selected community is valuable in the examination of cerebral vascular prevalence for reasonable remedy.<sup>10</sup> With the advancement of medical imaging, recent imaging procedures involve the Transcranial Doppler, DSA, CTA and MRA, of which DSA is the ideal approach.<sup>11,12,13</sup> Nonetheless, DSA is an intrusive technique, with a considerable amount of complications, such as radiation exposure, and regulation for contrast agent, and onwards. CTA is an outstanding diagnostic indicating modality; nevertheless, it also needs injection of contrast agent and susceptibility to radiation, with associated outcomes on bone and calcification.<sup>14</sup> MRA gives a chance for mirroring the vessels in the living. It is broadly utilized in practical training's and exploration due to non-intrusive, non-contrast and non-radiation

imaging characteristics, that has facilitated incredible betterment in the imaging of the intracranial vasculature for its structure and varieties. In this respect, we exp-lane that MRA is a relatively susceptible diagnostic modality to distinguish cerebral arterial pathological lesions or typical variants.<sup>15</sup>

The aim of this investigation was to assess and interpret the prevalence and forms of arterial variants and the unusual morphological and anatomical variations of the COW on MRA in adult Pakistanis.

## MATERIAL AND METHODS

In this descriptive review a total of 90 victims with ages 20-90 years, were selected for the study between July 2021 till October 2021 after permission from IRB. The patients were referred for screening MRA brain in the Department of Radiology of Shalimar Hospital, CMH, and Lahore General Hospital, Islamabad Diagnostic Centre, Lahore Pakistan. Adults both males and females above 20 years with or without cerebrovascular disease were included in this study. Infants, children and teenagers both males and females with or without cerebrovascular disease were not included in this study. The examination of variants of Circle of Willis MRA was conducted utilizing 1.5 T & 3 T MRI machine. The patients were supine then positioned in a head coil. The laser beam was centered localizer over the glabella. A three-plane localizer was taken in the beginning to localize and plan the sequence. The protocol selected to visualize the circle of willis was TOF Magnetic Resonance Angiography. Later, MIP (Maximum Intensity Projection) was used as a post-processing technique to visualize arterial network. Data were collected according to variables i.e., age, gender, anterior & posterior circulation (complete or incomplete). For analysis of data SPSS version 24.0 was used.

## RESULTS

Out of the 90 patients, 51(56.7%) were man and 39(43.3%) were women with overall mean age of 55 years (range:20/90 years). The study showed different anatomical variations of COW in adult patients on magnetic resonance angiography. The inclusion criteria were, all adult man and women patients with or without cerebrovascular diseases referred to the radiology department for

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MRA brain. Data analysis demonstrates that out of total 90 overall average age of 55 years (range:20/90 years). patients, 51(56.7%) were man and 39(43.3%) were women with

Table 1: Variants of Posterior Circulation \* Variants of Anterior Circulation Crosstabulation

Variants of Posterior Circulation		Variants of Anterior Circulation				Complete	Total
		AI segment of Left ACA is Absent	AI segment of Left ACA is Hypoplastic	AI segment of Right ACA is Absent	AI segment of Right ACA is Hypoplastic		
Complete	Count	2	3	6	6	66	83
	% Within Variants of Posterior Circulation	2.4%	3.6%	7.2%	7.2%	79.5%	100.0%
PI segment of Left PCA is Absent	Count	0	0	0	0	3	3
	% Within Variants of Posterior Circulation	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
PI segment of Left PCA is Hypoplastic	Count	0	0	0	0	2	2
	% Within Variants of Posterior Circulation	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
PI segment of Right PCA is Absent	Count	0	0	0	0	2	2
	% Within Variants of Posterior Circulation	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
Total	Count	2	3	6	6	73	90
	% Within Variants of Posterior Circulation	2.2%	3.3%	6.7%	6.7%	81.1%	100.0%

Overall, 66(79.5%) circles were complete in anatomical order and 24(20.5) were incomplete either due to absent/ hypoplastic PCA and absent/ hypoplastic ACA. The anterior circle was complete in 73(81.1%) subjects.

Table 2:

	Frequency	%age
Complete	73	81.1
AI segment of Left ACA is Absent	2	2.2
AI segment of Left ACA is Hypoplastic	3	3.3
AI segment of Right ACA is Absent	6	6.7
AI segment of Right ACA is Hypoplastic	6	6.7
Total	90	100

The anterior circle was incomplete in 17(18.9%) patients with AI segment of left ACA is absent in 2(2.2%) subjects, AI segment of left ACA is hypoplastic in 3(3.3%) subjects, AI segment of right ACA is absent 6(6.7%) subjects and AI segment of right ACA is hypoplastic 6(6.7%) subjects.

Table 3: Variants of Posterior Circulation

	Frequency	%age
Complete	83	92.2
PI segment of Left PCA is Absent	3	3.3
PI segment of Left PCA is Hypoplastic	2	2.2
PI segment of Right PCA is Absent	2	2.2
PI segment of Right PCA is Hypoplastic	0	0.0
Total	90	100

The posterior circle was complete in 83(92.2%) subjects and incomplete in 7(7.8%) subjects with PI segment of left PCA is absent in 3(3.3%) subjects, PI segment of left PCA is hypoplastic in 2(2.2%) subjects, PI segment of right PCA is absent in 2(2.2%) subjects and PI segment of right PCA is hypoplastic in 0(0.0%) subjects.

The most common variation of Circle of Willis was hypoplasia/absence of segments of Circle of Willis. ACA was mainly periodic segment of Circle of Willis that was hypoplastic/absent followed by A1 segment of right ACA is absent in 6(7.2%) subjects and A1 segment of right ACA is hypoplastic in 6(7.2%) subjects.

## DISCUSSION

Rehana Shaikh *et al*, in 2018 studied “MRA dependent assessment of anatomical differences of COW in adult Pakistanis”. The aim of their study was to discover the regularity & shapes of usual anatomical differences of Circle of Willis on MRA in adults without cerebrovascular disease. This illustrative fragmentary analysis was performed on objects assigned for magnetic resonance imaging of the brain. The outcomes of the 135 patients, 70 were males and 65 were females. Out of all the patients, 30 appeared a complete circle, while 82 and 23 had relatively complete and incomplete circles sequentially. It was concluded that there is a broad differences in the dissection of the Circle of Willis in Pakistani adults symptom-less for cerebrovascular disease.<sup>16</sup> In our study out of 90 subjects 51(56.7%) were male and 39(43.3%) were females. 66(79.5%) subjects showed complete Circle of Willis and 24(21.5%) subjects showed incomplete Circle of Willis.

Reddy Ravikanth *et al*, in 2019, did a cross sectional study named “MRA based variations in the COW: Result of vast series from only one center”. It was conducted from September 2014 to September 2016. This study was carried on 200 objects who introduced for screening for CVA. The result of their study was the frequent segment of COW in one center patients were anterior variant Type A and posterior variant Type E which concluded that the formation of the COW may vary highly in the universal community. The vast changes in the formation of COW wants more study on numerous races and large communities to authenticate the impact of inherited, geographical, habitual, and hemodynamic components.<sup>17</sup> In our study the most common type of variant of COW were of anterior circulation i.e., absence and hypoplasia of ACA segment.

In 2017, a study named “MRA survey of Anatomic Variations of the COW in a Population in Tehran” was conducted by Bahman Jalali Kondori *et al*, purpose of inquiry was to look over unrelated anatomic differences of the COW or its universality. Divisional examination was performed on 525 well patients together with 205 males and 320 females. Average age of subjects was 51.5 years. 3D TOF MRA procedure was utilized. Vascular changes in anterior & posterior segments of circle were assessed. Results manifested that the complete COW was clear in minority of subjects. COW had a complete circularity system in 20.9% of subjects while anterior section of COW had a complete circle in 80.95% of the patients. On other hand posterior section had a complete circle in 20.95% of patients. This concluded that it showed vast changes in COW formation in this examination.<sup>18</sup> In our study the results showed that the complete COW was clear in majority of subjects. The anterior part had a complete circle in 73(81.1%) patients while the posterior section had a complete circle in 83(92.2%) patients.

In 2018, a study named “MRA assessment of Anatomical Variations of the COW” was conducted by Fethi Emre Ustabaşoğlu *et al*. The aim of their survey was to rule out the patterns of the COW and its universality. Among all of 580 patients were taken in this examination. 3D TOF MRA procedure was utilized to assess anatomy of COW. Results concluded that the anterior section of COW had a complete circle in 82% of patients. The circulatory system of posterior section was complete in 22.2% of patients. It showed that posterior part changes are more common in COW assessment with MRA, and the most frequent segment was bilateral posterior communicating artery absence.<sup>19</sup> Our findings showed that the anterior segments variants are more frequent in Circle of Willis and the most frequent segment in our examination was hypoplastic and absence of A1 segment of right ACA.

## CONCLUSION

The study concludes that mostly the COW is complete in Pakistani adults. There are variations particularly in anterior part as compared to the posterior part of the COW. The most common variants are of A1 segment of Right ACA as compared to other type of variants.

**Conflict of interest:** Nil

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