e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2023; 15 (12); 1483-1488

Original Research Article

Study of Anatomical Variations of Circle of Willis – A Magnetic Resonance Study in North Karnataka Population - Retrospective Study

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Received: 25-09-2023 / Revised: 28-10-2023 / Accepted: 30-11-2023

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Conflict of interest: Nil

Abstract:

Background: Anatomical variations of branches of the circle of Willis are often studied by MRI. These normal anatomical variations have great importance in distinguishing occluded or embolised arteries.

Method: 40 (Forty) healthy volunteers aged between 25 to 55 years were studied. The technique used was three-dimensional times of flight magnetic resonance angiography (3D-ToF-MRA), and only the arteries forming the circle of Willis were studied. For the purpose of identification, COW is divided into anterior and posterior configurations.

Result: The variations of COW were 7 (38.9%) had ant cerebral artery hypoplasia, 4 (22.2%) had post cerebral artery hypoplasia, and 5 (27.7%) had analogous origin, and 2 (11%) had hypoplasia of the post communicating artery.

Conclusion: It is concluded that these anatomical variations with hypoplasa anomalous origin and attenuation of arteries must be known to neurologists, neurosurgeons, and radiologists for proper diagnosis of patients suffering from neurological diseases.

Keyword: Circle of Willis (COW), Hypoplasia, Anomalous, Stroke, Vertebra-Basilar.

Introduction

Circle Willis (COW) is a large arterial ring that unites the internal carotid artery and vertebral basilar systems. It forms an anastomosis between the internal carotid artery, anterior cerebral artery, communicating artery, posterior communicating artery, and posterior cerebral artery [1]. This anastomosis provides a vascular ring [2]. It has great importance because when any one of these major arteries gets occluded, it leads to neurological complications, and these anatomizing arteries will compensate for the occlusion by collateral circulation, but it also affects the hemodynamics of the circle of Willis because the circle of Willis is influenced by variations in the caliber of communicating arteries that lie between their origins and their junctions with the corresponding arteries; hence, the detailed knowledge of variations in diameters and branching of the circle of Willis must be known to radiologist, neuro-physician, neurosurgeons to differentiate the anatomical variations from any like stenosis, atherosclerosis, embolism, etc [3]. It can be viewed in a magnetic resonance imaging study; hence, an attempt is made to study the anatomical variation of COW in normal individual volunteers so that clinicians can easily differentiate the cause of variations, correlate with clinical studies, and treat efficiently such pathologically affected branches of COW [4].

Material and Method

40 (forty) patients aged between 25 to 55 years visiting the Radiology Department of MR Medical College Kalaburgi, Karnataka, were studied.

Inclusive Criteria: Healthy volunteers having no problems (or head and neck) are selected for the study.

Exclusion Criteria: Patients with anti-epileptic, vertigo, migraine, and neuro-vascular diseases, receiving antidepressants, or having a history of head injury are excluded from the study.

Method:

The technique used was three-dimensional time of flight magnetic resonance angiography (3D-TOF-MRA), and only the arteries forming the circle of Willis were studied. For the purpose of identification, the circle of Willis is divided into anterior and posterior configurations.

The anterior configuration consists of the anterior cerebral artery, the anterior communicating artery, and the internal carotid arteries. The posterior configuration, consisting of the communicating artery and basilar artery For the purpose of description, the segments of the anterior and posterior cerebral arteries are named as

- Anterior cerebral artery: a horizontal A1 segment that extends medially from its origin to its junction with the anterior communicating artery.
- Posterior cerebral artery: the pre-communicating artery extends laterally from its origin at the basilar bifurcation to its junction with the posterior communicating artery.

The duration of the study was from June 2023 to November 2023.

Statistical analysis: Variations of the arteries and hyperplasic arteries were classified by percentage. The statistical analysis was carried out in SPSS software. The ratio of males and females was 2:1.

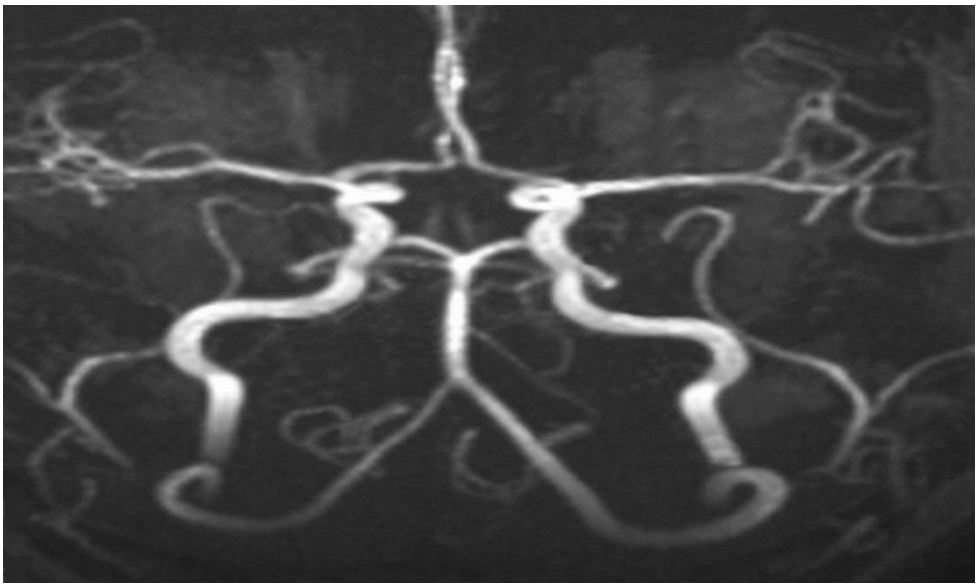

Figure 1: Circle of Willis MRI Image

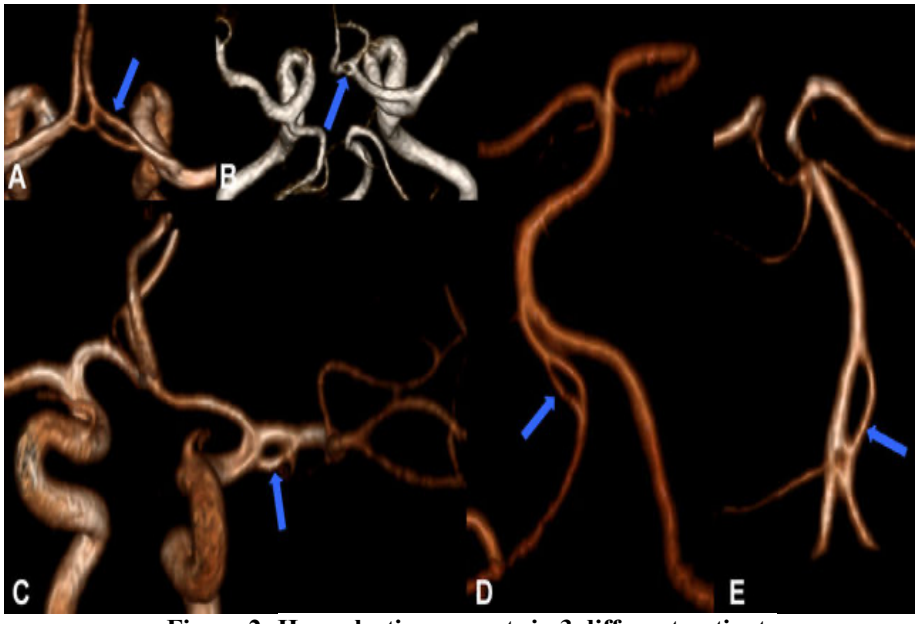

Figure 2: Hypoplastic segments in 3 different patients

Volume-rendered (VR) 3D time-of-flight MRA showing hypoplastic A2 segment (the second segment of the anterior cerebral artery [ACA]) (blue arrow) and hypoplastic A1 segment (first segment of ACA) (green arrow). Dominant A2

(gray arrow) is also known as bihemispheric anterior cerebral artery

Axial maximum intensity projection of CT angiography showing hypoplasia of the right Pcom (yellow arrow). Notice occlusion of the contralateral internal carotid artery VR 3D TOF MRA showing hypoplastic vertebral artery (orange arrow), which ends as posterior inferior cerebellar artery (white arrow).

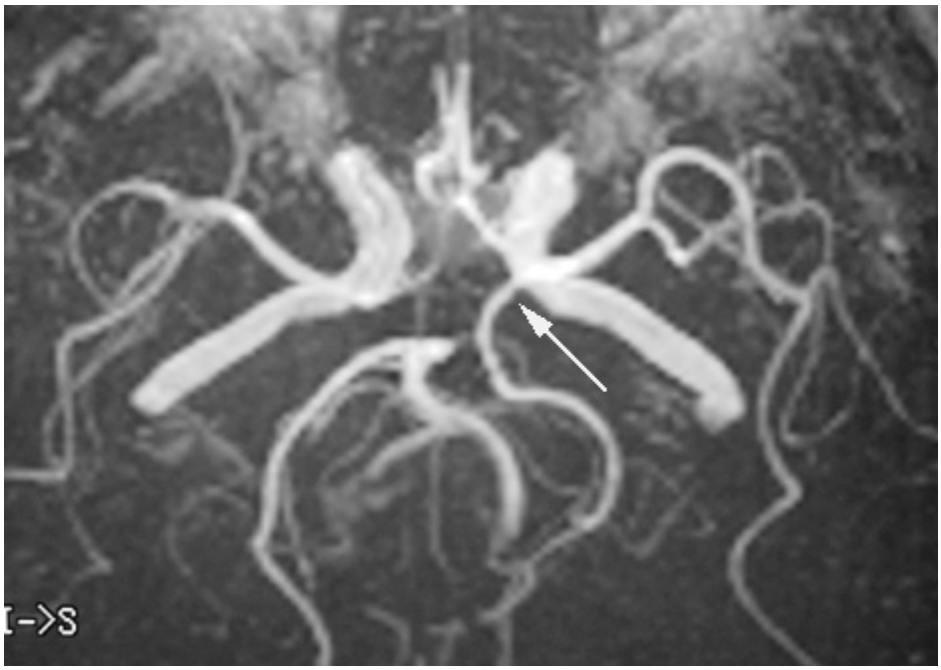

Figure 3: Anomalous origin of posterior cerebral artery MRI

Observation and Results

Table-1: Study of variation in circle of Willis out of 18 (45%) variations - 7 (38.9%) were hypoplasia of anterior cerebral artery, 4 (22.2%) hypoplasia of post cerebellar artery, and 5 (27.7%) had anomalous origin, 2 (11.1%) post communicating artery had hypoplasia.

Table-2: The present findings were compared with previous studies

Table 1: Study of variation in circle of Willis (Total no variation: 18)

Name of the vessel	Absent vessels	Hypoplasia	Accessory vessel	Anomalous origin	Percentage
Anterior cerebral Artery		7			38.9
Anterior Communicating Artery	--	--	--	--	--
Posterior cerebral artery	--	4 (22.2%)	--	5 (27.7%)	49.9
Posterior communicating Artery	--	2	--	--	11.1%

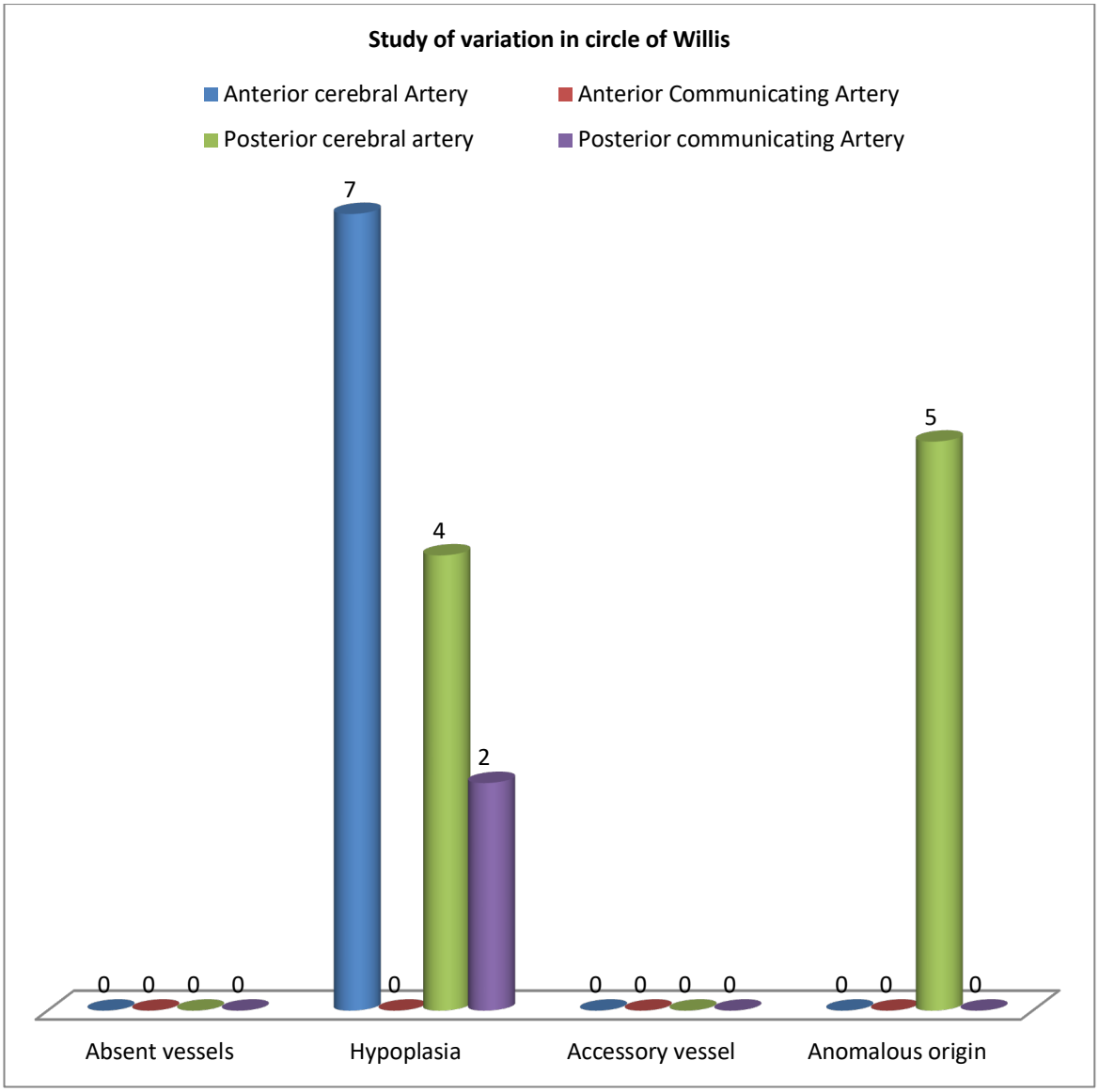

Figure 4: Study of variation in circle of Willis

Table 2: Comparison on of present study with previous workers

Name of the Author with year	Normal Pattern %	Variations %
Alpers et al. (1959)	52.3	47.7
Raja Reddy et al. (1999)	53.3	46.7
Kamath. S (1981)	56	44
Stephen and John (1991)	52	48
Mnachhi et al. (2002)	41	59
Raghavendra (2009)	56	44
Hartkamp et al. (2001)	42	58
Haripriyam and Metani (2010)	58	42
Jagedeesh Morab (2020)	58.1	41.8
Present study (2023)	55	45

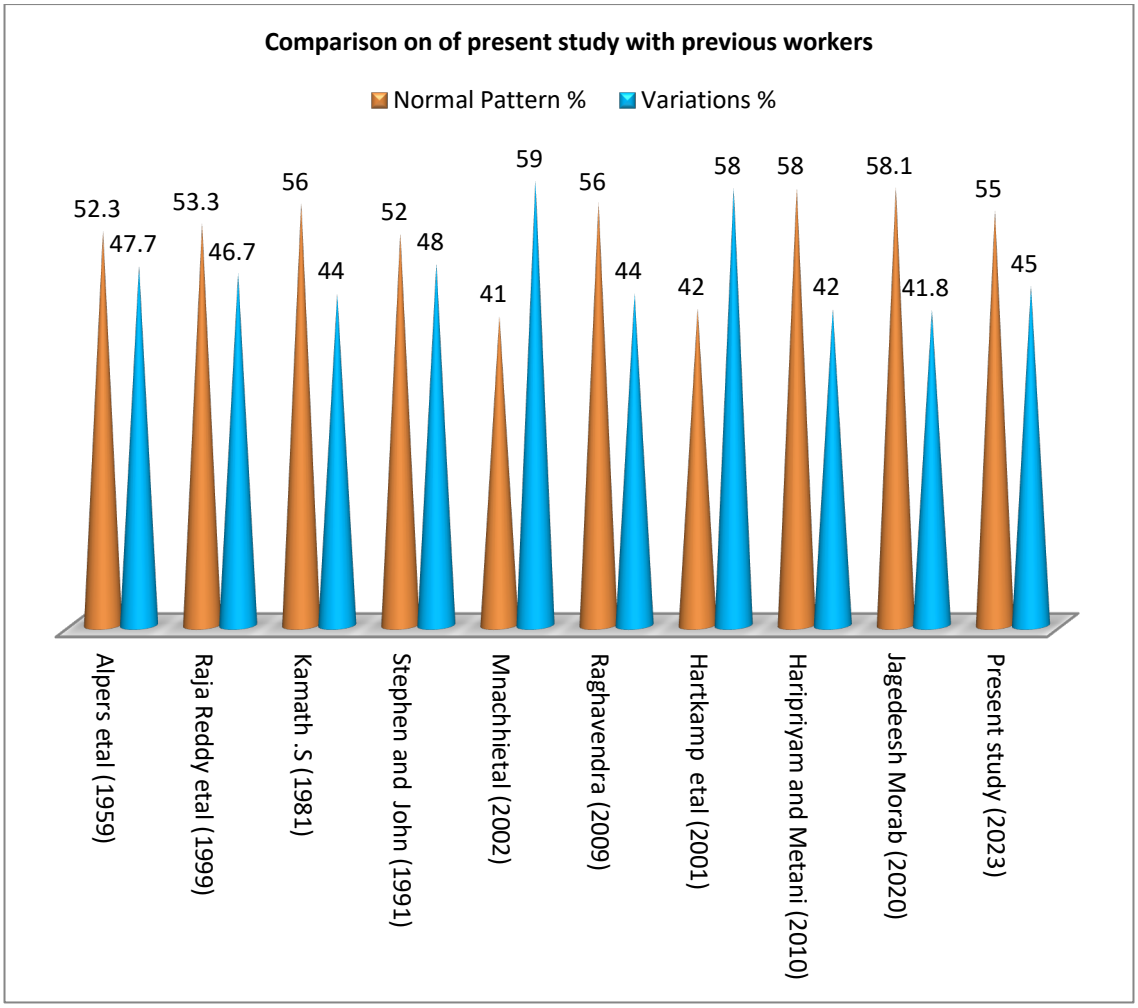

Figure 5: Comparison on of present study with previous workers

Discussion

The present study of anatomical variations of the circle of Willis (COW) was studied with magnetic resonance. It has 7 (38.9%) hypoplasias of the anterior cerebral artery, 4 (22.2%) hypoplasias of the post-cerebral artery, 5 (27.7%) anomalous origins of the post-cerebral artery, and 2 (11.1%) hypoplasias of the post-communication artery (Table 1) (figures 1, 2, and 3). These findings are more or less in agreement with previous studies (5)(6)(7). The exact cause of the variations is not found in English literature. Hence, it can be hypothesized that the variations of COW might be associated with age due to the suggestive factor of arthrosclerosis [8,9]. Moreover, a reduction in blood cerebral vessels leads to tortuosity with the advancement of age [10], could also alter the pattern of COW hence the absence of hypoplasia in COW. It is also reported that arteries pursue the shortest and most direct course in order to reach their objective, and this course is partly determined by mechanical convenience. In addition to this, the angle at which branches leave a main arterial stem certainly depends to a considerable extent on hemodynamic factors [11] to maintain erect posture and facilitate rotation of the head and neck against gravity because arterial vessels go upwards by overcoming [12].

The hurdles of gravity and erect posture might choose a short-cut pathway, causing variations in COW. It is also presumed that variations in the anatomical pattern may due to ethnic or racial differences or geographical variations.

Although MRI study is carried out in normal healthy volunteers, these variations may represent pre-diagnostic features of atherocurosis, thrombus or due to improper development of germ layers in fetal life due to mal nourished or under nourished pregnant women.

Summary and Conclusion

In the present anatomical variations of COW out of fifty, twenty-three (23) variations are encountered since we have a limitation of samples.

Hence, this study demands further genetic, nutritional, climatic, hormonal, and biomechanical study because the exact mechanism or factors of variations in COW are still unclear.

Limitation of study: Owing to the tertiary location of the research center, the small number of patients, and the lack of the latest techniques, we have limited findings and results.

This research paper has been approved by the ethical committee of MR Medical College Hospital in Kalaburgi, Karnataka.

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