

Variation of Arteries Forming Circle of Willis in Adult Human Cadavers

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ABSTRACT

Introduction

Circle of Willis is a large arterial anastomosis between internal carotid and vertebrobasilar arterial system. It is the principal collateral channel for constant blood flow to brain. Any changes in its morphology may cause vascular insufficiency of variable severity. Knowledge about its anomalies may elucidate occurrence of cerebrovascular disorders, its presentation, treatment, prognosis and prevention.

Methods

An observational study on 107 fresh cadavers was conducted at Maharajgunj Medical Campus from September 2016 to August 2017. After dissection of the scalp and removal of the vault and dura mater, the brain was obtained. Then the Circle of Willis was identified and observed for its completeness, symmetry, presence, origin and number of arteries forming it and the obtained data were documented, photographed and analyzed.

Results

Out of 107 cadavers, variations were noted among 15 (14%): out of which 10 were male and 5 female. Twelve cadavers had single variation while 3 had two variations. Accessory anterior cerebral artery was found in 7 (38.90%), fetal origin of right posterior communicating artery in 2 (11.10%), fetal origin of left posterior communicating artery in 4 (22.20%), early bifurcation of left posterior cerebral artery in 1 (5.60%), variant anterior communicating artery in 2 (11.10%), fused anterior cerebral artery in 1 (5.60%) and aneurysm in 1 (5.60%) subjects were found.

Conclusion

Variations were noted among 15 cadavers (14%), 12 cadavers had single variation while 3 had two variations. The most common variation seen was accessory anterior cerebral artery found in 7 cadavers (38.90%). Most of the variations were found in midline anteriorly followed by right side.

Keywords: *Aneurysm, cerebrovascular disorder, circle of Willis, stroke, variant*

INTRODUCTION

The Circulus arteriosus (Circle of Willis) is a large polygonal arterial anastomotic channel at the base of brain formed by union of internal carotid and vertebrobasilar arterial system. It has anterior communicating artery in front, two anterior cerebral arteries anterolaterally, proximal segments of both internal carotid arteries laterally, two posterior communicating arteries posterolaterally and proximal segment of both posterior cerebral arteries which are derived from the bifurcating terminals of the basilar artery behind.^{1,2}

The Circle of Willis provides a collateral blood flow to the brain during severe occlusive diseases. Variation in arteries forming Circle of willis may lead to vascular insufficiency like transient ischemic attack (TIA) and stroke of high or low risk depending upon presence of sufficient collateral supply or not.^{3,4} The arteries of circle have many variations in different forms like in their formation, development and size.⁵ Different abnormalities such as absence, split, hypoplastic and accessory vessels had been observed.⁶⁻¹⁰ Anatomical variations are probably genetically determined, develop in early embryonic stage and persist in post-natal life.¹¹

Hence the knowledge of Circle of Willis is important and should be considered during angiographic evaluation and neurosurgical procedures.

METHODS

A total number of 107 adult cadavers (77 male and 30 female) were studied. Fresh cadavers of Nepalese nationals with intact brain in case of hanging, stab injury, myocardial infarction etc. were included whereas cadavers sustaining injuries to head, putrefied cadavers, cadavers of foreign nations and pediatric age group were excluded.

After due ethical permission from Department of Forensic Medicine and Toxicology, Maharajgunj Medical Campus, Maharajgunj, autopsy was started placing the cadavers in a supine position on the autopsy table. A wooden block was placed under the back of the head. A sharp scalpel was

used to incise the layers of the scalp from behind the ear of one side, over the top of the head to behind the ear of the other side; the front flap was pulled forward over the cadaver's face. The back flap was pulled backwards over the nape of the neck. The cap of the skull was removed with the circumferential incision one centimeter above the supraorbital margin anteriorly and external occipital protuberance posteriorly, using a saw and hammer.

The skull cap was removed and the dura mater was incised from frontal crest and crista galli anteriorly, extending backwards to the internal occipital protuberance on either side of superior sagittal sinus, then supporting the occipital lobes the brain was freed from cranial fossa after cutting olfactory nerves, optic nerves, internal carotid arteries, infundibulum and oculomotor nerves sequentially. The attached margin of tentorium cerebelli, on both sides, was incised along the posterior clinoid processes, superior borders of petrous part of temporal bone, and the margins of the grooves for transverse sinuses on the occipital bone, using a long and pointed knife. Fax cerebelli was also cut from the margins of the groove for occipital sinus. A long, thin knife was then used to incise the rest of the cranial nerves; the medulla oblongata was incised at the level of foramen magnum and the brain was then gently lifted out of the cranium.

The base of the brain in each specimen was cleaned and cerebral arterial circle of Willis was identified. The arachnoid mater was removed from the arteries and areas around it. Completeness, symmetry, presence, origin and number of component vessels of Circle of Willis along with presence of any aneurysms were noted. Magnifying lens was used to observe the vessels closely. The obtained variations were documented and photographed.

RESULTS

Out of the studied 107 total cadavers, 77 were male and 30 were female. Females were 18 to 54 year old while males were 18 to 63 year old. Variations were noted in 15 cases (14%) out of which 10 cadavers were male while 5 cadavers were female. Of the

Table 1. Frequencies and percentage of variant arteries in male, female and total population

Variant artery	Total	Female	Male
Accessory anterior cerebral artery	7 (38.90%)	3 (50.00%)	4 (33.30%)
Fetal origin of right posterior communicating artery	2 (11.10%)	0 (0%)	2 (16.70%)
Fetal origin of left posterior communicating artery	4 (22.20%)	1 (16.70%)	3 (25.00%)
Early bifurcation of left posterior cerebral artery	1 (5.60%)	1 (16.70%)	0 (0%)
Aneurysm	1 (5.60%)	0 (0%)	1 (8.30%)
Accessory anterior communicating artery	2 (11.10%)	1 (16.70%)	1 (8.30%)
Fused anterior cerebral artery	1 (5.60%)	0 (0%)	1 (8.30%)
Total	18 (100.00%)	6 (100.00%)	12 (100.00%)

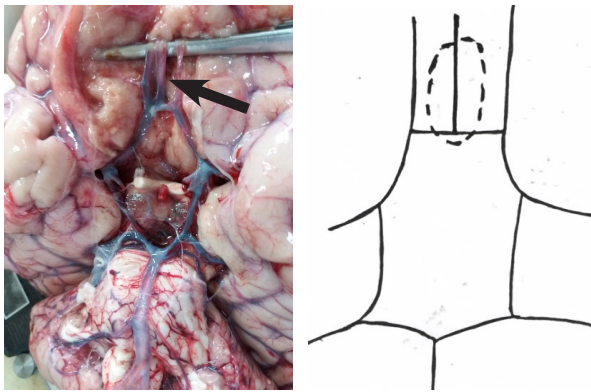


Fig 1. Photograph of single accessory anterior cerebral artery (arrow) and schematic (encircled)

total 15 total variant cases, 12 had single type of variation while 3 had two types of variation. Total variations were found in 18 arteries from 15 cases as shown in Table 1. The most common variation encountered was accessory anterior cerebral artery found in 7 cadavers (38.90%) which has been shown in Figure 1.

Midline variations of accessory ACA were observed in 8 cadavers which amounted to 53.3% of total variations. Right sided variation was found in two cadavers (13.3% of total variations), while left sided variation was found in 4 cadavers (26.7% of total variations). Bilateral variations was present in one cadaver (6.7% of total variations).

Anterior variations were most common, found in 9 cadavers which accounted for 60% of total variations. Posterior variations was found in 5 cadavers (33.3% of total variations) while variation in both anterior and posterior artery was present in 1 cadaver (6.7% of total variations)

The P1 segment of posterior cerebral artery lies from bifurcation of basilar artery to junction with posterior communicating artery. So when the diameter of the ipsilateral P1 segment is less than the diameter of Posterior communicating artery, it is known as fetal configuration of posterior communicating artery.¹²

DISCUSSION

This study focuses on the occurrence of variation according to side which showed more variation in midline (53.3%) followed by left side (26.7%). More variation in left side in comparison to right side were seen in some studies.^{13,14} whereas some study showed more variation on right side than left.¹⁵ In the current study, the anterior part of circle has more variations (60%) than posterior part of circle (33.3%) The difference in studies could be due to genetic and developmental influences.¹¹ Anterior cerebral artery showed maximum variations in this study, similar to other study.¹⁶ The variations seen in

anterior cerebral artery are fused anterior cerebral artery and accessory anterior cerebral artery. Accessory anterior cerebral artery was the common variation found in this study (38.9%) among which 2 accessory ACA was found in 1 cadaver. The study can be comparable to other studies.¹⁶⁻¹⁸ Anterior communicating artery exhibits doubling abnormalities. This was seen in 11.1% cases in the current study. This finding was largely in accord with observation of other studies.¹⁸⁻²²

In this study after anterior cerebral artery second most common variation was found in posterior communicating artery. Current study showed fetal origin of right posterior communicating artery in 33.3% and fetal origin of left communicating artery in 26.7%. The fetal origin of posterior communicating artery was also seen in other studies.²²⁻²⁵ The only variation seen in posterior cerebral artery was early bifurcation (branching) of left side of posterior cerebral artery and no any variations were found in right side. Other miscellaneous variation like aneurysm was found in 6.7% in this study at the junction of right anterior cerebral artery and anterior communicating artery.

CONCLUSION

The present study has constructed a data on variation of arteries forming Circle of Willis in adult Nepalese cadavers. Out of 107 adult cadavers variations were noted among 15 cadavers (14%), 12 cadavers had single variation while 3 had two variations. The most common variation in the present study was accessory anterior cerebral artery found in 7 cadavers (38.90%). Most of the variations were found in midline anteriorly followed by right side. Though the sample size was very small to represent all the adult Nepalese population, this attempt may open up further paths to construct baseline data on variation of arteries forming Circle of Willis in Nepalese people.

CONFLICT OF INTEREST

None declared.

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