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Surgery

A STUDY OF VARIOUS FORMATIVE PATTERN OF CIRCLE OF WILLIS IN ADULT HUMAN CADAVERS AND USING MAGNETIC RESONANCE IMAGING

Dr Sreekanth matcha	Assistant professor, department of surgery, Gitam institute of medical sciences, Gitam University, Visakhapatnam.
Dr Ramadevi Gara*	Assistant professor, department of Anatomy, Gitam institute of medical sciences, Gitam University, Visakhapatnam. * Corresponding Author
Dr Radha Ramani. B	Assistant professor, department of Anatomy, Gitam institute of medical sciences, Gitam University, Visakhapatnam.

ABSTRACT **Objectives of study:** The major arteries that supply the cerebrum are joined to one another at the base of the brain in the circle of Willis. Normally, little exchange of blood takes place between the main arteries through the slender communicating vessels. The arterial circle provides alternative routes, however, when one of the major arteries leading into it is occluded. The hemodynamic of the circle is influenced by the variation in the caliber of communicating arteries and main arteries. The objective of the present study are to study the formation and branching pattern of circle of willis and also distribution of variations in cadavers and using magnetic resonance imaging. **Materials and methods:** Study was conducted on 50 cadaveric specimens and 100 radiological films based on magnetic resonance angiography. Brains were removed carefully from the cranial cavity and immersed in 10% formalin for fixation. The circle of Willis of each brain was dissected carefully. The pattern of the arterial circle and related variations were noted simultaneously. **Interpretation and Conclusion:** Attenuated vessels are most common anomaly that found during the study in both cadavers (12%) and MRA (26%). Other anomalies that found were accessory vessels, aplastic vessels, and anomalous origin of vessels.

KEYWORDS : circle of Willis, anterior cerebral artery, middle cerebral artery, posterior cerebral artery, anterior communicating artery.

INTRODUCTION:

Willis was the first to recognize the importance of the circle in maintaining collateral flow to the brain. [1] The correct recognition of the arterial ramifications at the base of the brain had a long and gradual evolution, and it appears that many anatomists had a hand in describing and illustrating the circle. The brain is supplied by the paired internal carotid and vertebral arteries through an extensive system of branches. The major arteries that supply the cerebrum are joined to one another at the base of the brain in the circle of Willis. Starting from the midline in front, the circle consists of the anterior communicating, anterior cerebral, internal carotid (a short segment), posterior communicating, and posterior cerebral arteries; then it continues to the starting point in reverse order. Normally, little exchange of blood takes place between the main arteries through the slender communicating vessels. The arterial circle provides alternative routes, however, when one of the major arteries leading into it is occluded. Frequently, these anastamoses are inadequate, especially in elderly people in whom the large vessels and communicating arteries may be narrowed by atheroma. Numerous central arteries arise from the region of the arterial circle as four groups. These slender, thin-walled blood vessels, also known as ganglionic, nuclear, striate, or thalamic perforating arteries, supply parts of the corpus striatum, internal capsule, diencephalon, and midbrain. The medial striate artery (recurrent artery of Heubner) is similar to the central arteries with respect to its distribution, as are the anterior and posterior choroidal arteries with respect to parts of their distributions. Human brain represents 2% of body weight; brain is one of the most metabolically active organs of the human body. [2] The continuous blood supply to the brain is of importance because of its high metabolic demand for oxygen and glucose. [3] It is highly sensitive to hypoxia and hypoglycaemia. [4] The abnormal arteries and the absent arteries are considered in this study as anomalies as they rise to incomplete circle of Willis. Other morphological differences which do not result in an incomplete circle of Willis are considered as anatomic variations. The basic criterion for considering the circle as anomalous was being unable to maintain an adequate blood flow. Alpers et al in their study defined that blood can circulate from any entrance point and return the same point.[5]

Variations of circle of Willis are clinically important as the circle of Willis plays important role in cerebral hemodynamic. Several studies have reported a range of variation in the anatomy of the circle of Willis as a whole. However, there exists difference in anatomic variations due to different races of populations. Present study is done collaboratively in both cadavers and MRA. Magnetic resonance angiography enabled evaluation of the intracranial vessels without need for invasive procedures like catheter angiography. There are very few studies on circle of Willis variation done by using both cadavers and MRA. The existing data in this study based on both so that it will contribute to our current knowledge in anatomical variations between different populations.

METERIALS AND METHODS:

Study was conducted on 50 cadaveric specimens and 100 radiological films based on magnetic resonance angiography. Specimens were collected from human cadavers (males and females) donated to Andhra medical college , Visakhapatnam for dissection and research purpose over last 10 years .only cadavers with known identity were selected and all were originated from Andhrapradesh region , aged between 25 to 75 years .Brains were removed carefully from the cranial cavity and immersed in 10% formalin for fixation. Each brain was placed over glass-wool in separate container to avoid damage. The circle of Willis of each brain was dissected carefully. The arterial circle was studied, photographed and numbered. The pattern of the arterial circle and related variations were noted simultaneously. Radiological study conducted on 100 films, the study includes subjects of adult age groups and of both sexes. The study was conducted in the department of radiology, Andhra medical college, Visakhapatnam.

RESULTS:

Based on the study we conducted by using both cadavers and MRA the observations made are categorized in to normal circles and anomalous circles.

The following are the anomalies that encountered during study

1. Attenuated vessels (hypoplasia)
2. Accessory vessels (duplication)
3. Absence of vessels (aplasia)

Attenuated (hypoplasia) vessels:

Fig-1 hypoplasia of left vertebral artery

Fig- 2 hypoplasia of right vertebral artery

Fig- 3 hypoplasia of A1segment of right ACA

Fig-4 Duplication left superior cerebellar artery.

Aplasia:

Fig-5 Aplasia of A_1 segment of ACA& Rt VA

ACA- anterior cerebral artery
VA- vertebral artery
PCA- posterior cerebral artery

DISCUSSION:

The observations made during the present study on the circle of Willis in both cadavers and MRA were compared with those recorded in earlier studies on the same topic. The prevalence of the typical circle i.e., the "normal text-book" polygon ranges from 4.6% [1] to 72.2%. [6] In the present study 25 % of the circles in cadavers and 46% MRA exhibited the normal configuration. This was compared with the other studies with in the Indian and other than Indian population.

The most common anomaly of the circle of Willis in normal brains was hypoplasia of one or other components of the circle. Arteries of less than 1 mm in external diameter were considered hypoplastic, except for the communicating arteries, where less than 0.5 mm was considered hypoplastic. Such hypoplastic vessels were encountered either alone or in combination with other anomalies. Most frequent anomaly that encountered in this study was hypoplastic vertebral artery, followed by the circular part of the anterior cerebral artery (A-1 segment), circular part of the posterior cerebral artery (P-1 segment) and the posterior communicating artery in both MRA and cadavers. Vertebral artery hypoplasia is the product of the delayed development of the vertebrobasillar artery and might be associated with anomalies in posterior circulation. It is important to distinguish between acquired narrowing and hypoplasia of the vertebral artery because each of these has different atherosclerotic burden. Katsanos AH et al in his study discussed the relationship between a hypoplastic vertebral artery and posterior circulation cerebral ischemia. [10] Chuang YM et al described the role of A_1 segment hypoplasia in acute ischemic stroke. [11]

Accessory vessels in the form of duplications/triplications involving one or more arteries were frequently encountered in the anterior portion of the circle of Willis. Among the accessory vessels, duplications/triplications of superior cerebellar arteries were commonly occurred followed by triplicate posterior cerebral arteries. Uchino A et al described the variations of superior cerebellar artery. [12] Agenesis and aplasia signify total absence of the vessel. In the presence of the aplasia of P1 segment of PCA, blood supply to the occipital lobe would be solely dependent on intact ICA while in the presence of the aplasia of PCoA blood supply to the occipital lobe would be solely dependent on intact vertebrobasillar artery. In this study we found the aplasia of A_1 segment of anterior cerebral artery, absent left vertebral artery and absent left posterior cerebellar artery. Similar observations were found by Uchino A et al. [13]

Most of the arterial variations of circle of Willis may not affect the brain function due to the collateral circulation and compensation from the arteries of the other side. But these variations gain profuse clinical importance when conditions like atherosclerosis, ischemia, and stroke.

SUMMARY AND CONCLUSION:

Anatomical variations are probably genetically determined, develop in early embryonic stage and persist in postnatal life. Any change in normal morphology of the circle may lead to the appearance and severity of symptoms of cerebrovascular disorders, such as aneurysms and arterial variations are interconnected. A thorough knowledge of the variations of vessels is useful to surgeons in planning their shunt operations and the choice of the patients. Anomalies of the circle of Willis play an important role in the occurrence, manifestation of symptoms, treatment options and recovery process of certain cerebrovascular disorders. Present study may helpful to add further note on variations of circle of Willis in the region of Andhra Pradesh.

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