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ORIGINAL RESEARCH PAPER

Neurosurgery

AN OBSERVATIONAL STUDY IN THE HUMAN CADAVERIC BRAINS REGARDING ANATOMICAL VARIATIONS IN THE CIRCLE OF WILLIS IN SOUTH INDIAN POPULATION

KEY WORDS: : ACA, CW, PCA, MCA, Bifurcation, Variations of circle of Willis

Dr. A . Thiruvalluvan Ms., Mch Neurosurgery Professor And Director, Institute Of Neurosurgery, Madras Medical College, Chennai. Tamilnadu.

Dr. Azeem* M. Ch (Neurosurgery) Post Graduate, Institute Of Neurosurgery, Madras Medical College, Chennai. Tamilnadu. *Corresponding Author

ABSTRACT

Background: The circle of Willis encircles the stalk of the pituitary gland and provides important communications between the blood supply of the forebrain and hindbrain (ie, between the internal carotid and vertebro-basilar systems following obliteration of primitive embryonic connections).Although a complete circle of Willis is present in some individuals, it is rarely seen radiographically in its entirety; anatomical variations are very common and a well-developed communication between each of its parts is identified in less than half of the population. In the present study, anatomical variations in the circle of Willis were noted in the cadaveric brain.

Methods: 189 apparently normal formalin fixed cadaveric brain specimens were collected from forensic department of Madras medical college, Chennai.

Results: 102 Normal anatomical pattern and 87 anatomical variations of circle of Willis were studied. The most common variation observed is in the anterior communicating artery (Broad communicating) followed by other variations in the postesrior cerebral arteries, Anterior cerebral artery and middle cerebral artery was found.

Conclusions: Thorough Knowledge on of variations in the formation of Circle of Willis have a great impact on the successful outcome of Neuro interventions. Hence all neurosurgical interventions should be preceded by angiography.

INTRODUCTION

The cerebral hemispheres and the walls of the diencephalon are supplied by both the carotid and the vertebral systems which anastomose remarkably to form 'the circulus arteriosus'. It is formed by the internal carotid artery which is interconnected via the anterior cerebral arteries on both the sides (right and left) and an anterior communicating artery which connects the right and the left anterior cerebral arteries. The carotid system is connected to the posterior cerebral arteries of the vertebral system by two posterior communicating arteries (right and left). This arterial circle is more commonly called 'the circle of Willis', named after Thomas Willis (1621 – 1673) who was an English physician. The circle of Willis has an important role in maintaining a stable and constant blood flow to the cerebral hemisphere. Most of the anatomical variations have been reported on the anterior cerebral and anterior communicating arteries. However there are very few case reports regarding the variations encountered in the PCA and PCoA. Hence, the present study was undertaken to study the origin, course and variations of circle of willis.

METHODS

189 human brain specimens irrespective of any particular age group were removed from embalmed cadavers. The brains were removed en-mass by adopting the dissection procedures as given in the Cunningham's 'manual of practical anatomy' volume III: head and neck and brain. The meninges were removed carefully from the interpeduncular fossa and the circle of Willis along with the major arteries was dissected and observed in situ.

The detailed study of the circle of Willis was made and findings were noted and tabulated with reference to position and course of ACA, MCA, PCA, PCoA and ACoA, its completeness and any anomalies encountered.

The cap of skull, was removed with the circumferential incision one centimetre (1 cm) above the supraorbital margin anteriorly and external occipital protuberance posteriorly, by using a saw. A hammer was used to separate the skull cap 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. The occipital lobes were supported with one hand while the other hand was used to free the brain from the cranial fossae. First, the olfactory nerves were gently cut by elevating frontal lobe from anterior cranial fossa. Next, the optic nerves were cut, followed by cutting both internal carotid arteries, infundibulum and oculomotor nerves. 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. Falx cerebelli was also cut from the margins of the groove for occipital sinus. The cerebellum was gently pushed back. 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 specimen obtained was washed with tap water and placed in a labelled container having 10% formalin solution. After fixation, the base of 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. The specimens were duly numbered and sorted out according to classification of the morphological variation of different components of Circle of Willis. Variations of all the segments were noted and were photographed. The variations such as hypoplasia, aplasia, duplication, fenestrations, were noted. Observations regarding shape, completeness, symmetry, abnormal architecture were noted. Lastly photographs of the abnormal specimens were taken.

RESULTS

In the present study total 189 fixed human brains were studied. Out of total 189 human brains, 102(53.34%) brains has been found to Confirm the classic form of 'Circle of Willis', that was, complete, symmetrical, normal calibre and heptagonal in shape. These 102 specimens have, therefore, been considered as 'Normal'. The rest 87 specimens (46.66%) of human brain were found as 'variations'.

Fifteen different types of variations of circle of Willis are found in this present study. Classical type of Circle of Willis was seen in 102 specimens. The variations are as follows

1. 2.6 % of Azygous ACA
2. 8.4% Broad communicating ACoA
3. 4.2% Fetal PCA
4. 4% of Hypoplastc PCoA
5. 1.05% of Hypoplastic Left PICA
6. 4.7% of Left PICA looping far downward
7. 2.1% of Hypoplastic Left PCA
8. Variations in MCA Bifurcation-(Multiple trunks-6.8%, inferior

trunk dominant-4.7%, superior trunk dominant-1.05%)
9. MCA Trifurcation – 1.5%
10. Cranial Nerve 3 lying above both PCA, SCA-1.5%
11. Cranial Nerve 3 ling between PCS, SCA on right and below SCA on left – 1.05%
12. Premature branching of A2 segment-1.05%
13. Cranial nerve 5 above bifurcation of SCA –0.5%
14. Cranial nerve5 abutting left of bifurcation of SCA-1.5%
15. Cranial nerve 5 within branching of SCA-0.5%

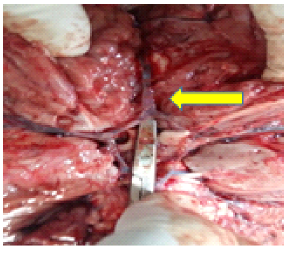
The same was depicted in tables and charts

TABLE 1

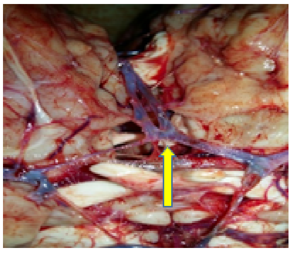
ANATOMICAL VARIATIONS	NUMBER	PERCENTAGE
Azygous ACA	5	2.6%
Broad communicating ACoA	16	8.4%
Fetal PCA	8	4.2%
Hypoplastic PCoA	4	2.1%
Hypoplastic Left PICA	2	1.05%
Left PICA looping far downward	9	4.7%
Hypoplastic Left PCA	4	2.1%
Premature branching of A2 segment	2	1.05%

PICTURES

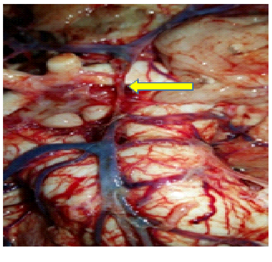
FIG 1 AZYGOUS ACA



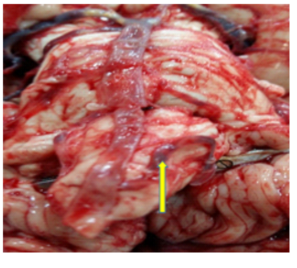
2. BROAD ACoA



3. FETAL PCA



4. LEFT PICA LOOPING FAR DOWNWARD THANRIGHT



5.PREMATURE BRANCHING OF A2

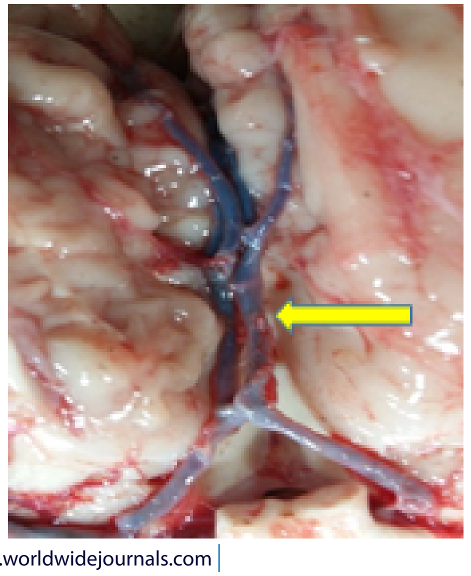
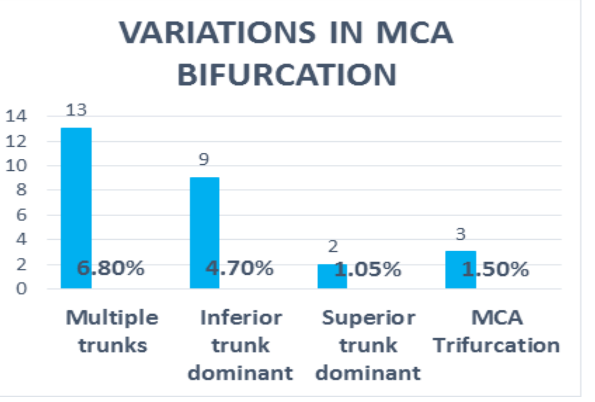
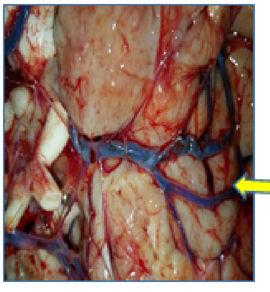


CHART 1



MCA bifurcation-Multiple trunks



MCA bifurcation Inferior trunk dominant

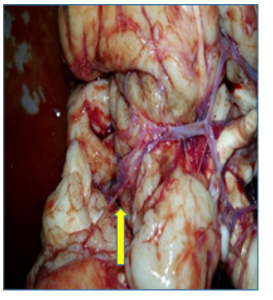
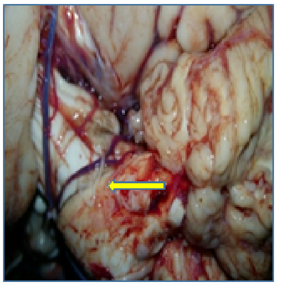


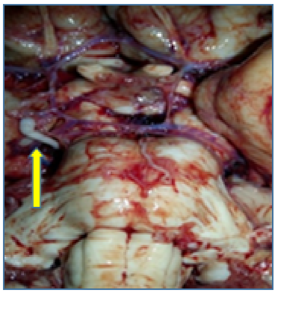
TABLE 2

VARIATIONS IN RELATION TO CRANIAL NERVE 3 & 5	PERCENTAGE
Cranial Nerve 3(oculomotor nerve) lying above both PCA, SCA(figure 2)	1.5%
Oculomotor nerve lying between PCA, SCA on right and below SCA on left	1.05%
Trigeminal nerve above bifurcation of SCA	
Trigeminal nerve abutting bifurcation of SCA (figure 1)	1.5%
Trigeminal nerve within branching of SCA	0.5%

Trigeminal nerve abutting Bifurcation of SCA



Oculomotor nerve lying above Both PCA AND SCA



DISCUSSION

Blood supply to the brain is mainly from the circulus arteriosus. Thomas Willis was pioneer in describing circle of Willis in 1962.Since then, many authors have reported number of anatomical variations in the formation of circle of Willis. Variations of the origin and distribution of the arteries at the base of the brain are common.

All these variations are either due to the disappearance of the vessels that normally persist or the persistence of the vessels that normally should disappear or formation of new vessels due to hemodynamic factors. In most of the arterial variations, the brain function may not be affected due to the collateral circulation and compensation from the arteries of the other side. A thorough knowledge of the variations in cerebral arterial circle has grown in importance with the increasing number of procedures like aortic arch surgery, microsurgical clipping of anterior communicating artery aneurysms; its variations are common and the textbook picture of symmetrical, large, approximately equal sized vessels were present only in 30% subjects.

According to Tanaka et al, variations in the circle of Willis correlate significantly with relative contributions by the flow rates of the bilateral internal carotid and basilar arteries, which might significantly contribute to the clinical importance of the variations. According to Alastruey et al, in normal subjects, the system does not require collateral pathways through communicating arteries to adequately perfuse the brain. The communicating arteries become important in cases of missing or occluded vessels.

It has been reported that the beginning, course, and result of the cerebral-vascular diseases depend hugely on the possibility of establishing collateral blood circulation, especially at the level of circle of Willis. The circle of Willis, through its communicating segments, provides an alternative route for the blood to reach parts of the brain which, due to insufficiency, do not receive enough quantity of blood. However, in cases such as the one reported here, due to the absence of communicating arteries, the alternative routes may not be available

CONCLUSION

In the present study, complete Circle of Willis was seen in53.34%. Gross variations were present in 46.66%. Maximum variations were present in the PCoA 22% followed by the ACoA in 13.33%, respectively. As it confirms high percentage of variations in the formation of Circle of Willis, all surgical interventions should be preceded by angiography, Awareness of these anatomical variations is important in the neurovascular procedures

Abbreviations:

ACoA : Anterior communicating artery
ACA : Anterior cerebral artery
SCA : Superior cerebellar artery
PCA : Posterior cerebral artery
PCoA : Posterior communicating artery
MCA : Middle cerebral artery

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