Research Paper Medical Science

The Study of Variations of Circle of Willis In Cadaveric Human Brains

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ABSTRACT

Background & objective: Cerebrovascular diseases such as stroke, aneurysms and arterio-venous malformations are very much prevalent in our country. Circle of Willis, as an anastomotic polygon at the base of the brain forms an important collateral network to maintain adequate cerebral perfusion. Changes in the normal morphology of the circle may condition the appearance and severity of symptoms of cerebrovascular disorders, such as aneurysms, infarctions and other vascular anomalies. The objective of the present study is to study the formation and branching pattern of circle of willis and also to study the distribution of variation. Materials & Methods: A total of 70 brain specimens were collected, cleaned and dissected. A careful examination of the specimens was done to check for variations in components of the Circle of Willis. Results: Thirty two number of variations were found in 20 brains in which there were more than one variation in the same specimen. Maximum variations were seen in the ACA followed by the PCoA in 28% and 25%, 22% of variations in PCA, 19% of variation in ACoA, 6% of variation in basilar artery were found in the present study. Conclusion: As it confirms high percentage of variations, all surgical interventions should be preceded by angiography. Awareness of these anatomical variations is important in neurovascular procedures.

KEYWORDS Circle of Willis, Anterior Cerebral Artery, Middle Cerebral Artery, Posterior Cerebral Artery, Anterior communicating artery, posterior communicating artery

INTRODUCTION

The brain is one of the most metabolically active organs of the human body [1]. The continuous blood supply to the brain is of importance because of its high metabolic demand for oxygen and glucose [5]. It is highly sensitive to hypoxia and hypoglycemia [9]. The brain is supplied by paired internal carotid and vertebral arteries. Two vertebral arteries unite to form basilar artery [5]. The Circle of Willis which lies in the inter peduncular fossa at the base of the brain is formed by the anastomosis between the internal carotid arteries, the basilar artery and its branches Estimation has revealed that among all the neurological disease of the adult life, the cerebro vascular ones, clearly ranks the first in its frequency and importance. The incidence of the cerebro-occlusive disease in human is ever demanding the attention and so further study, about the pattern of arterial variations that occur in the human brain. The diagnosis and treatment depends on the knowledge of the anatomy of the particular system concerned. Many disturbances in the nervous system functioning, arises as a consequence of impaired circulation. By knowing the distribution of blood supply to the brain and its functional anatomy, it is often possible to analyze which particular vessel is affected. Considering the above mentioned factors and importance of the understanding of the depth of the knowledge of the circle of Willis and thereby to help in throwing a better light and guide on to the surgical procedures and invasive and non-invasive techniques. This study was to assess the pattern and incidence of variation in the Circle of Willis on human brain.

MATERIALS AND METHODS

Seventy adult human brains were used in this study. The brain specimens were collected from the Department of Anatomy, Madurai Medical College & Hospital. Circulus arteriosus was studied on 70 formalin preserved brains of human cadavers. The brain specimens were dissected with a fine pair of scissors and forceps, the arachnoid matter was removed at the interpeduncular fossa carefully, and the circle of Willis was visualized and studied and documented the pattern of circle and its variations.

OBSERVATIONS & RESULTS

Out of 70 adult human brains dissected 20 brains showed anomalies of different vascular components of the circle of Willis. They are tabulated with reference to each of the following vessels.

1. Abnormal pattern of basilar artery.
2. Variation in the pattern of Posterior cerebral artery.
3. Variation in the pattern of Posterior communicating artery.
4. Variation in the pattern of Anterior cerebral artery.
5. Variation in the pattern of Anterior communicating artery.
6. Aneurysm
7. Variation in the size of the vessel.
8. Anomalous origin of vessels.

Tab :1 32 NUMBERS OF VARIATIONS WERE FOUND OUT OF 20 BRAINS IN WHICH THERE WERE MORE THAN ONE VARIATION IN THE SAME SPECIMEN

S.no	PATTERN OF VARIATION	No.
1	anterior cerebral artery	9
2	anterior communicating artery	6
3	posterior communicating artery	8
4	posterior cerebral artery	7
5	basilar artery	2
	Total	32

1.VARIATION OF THE ANTERIOR CEREBRAL ARTERY

The Anterior cerebral artery showed a large vessel one on the right and one on the left side.There was a specimen with thin left anterior cerebral artery. One specimen showed double vessel on the right side. In one specimen there was a single anterior cerebral artery. Aneurysm was noted on the left side in four specimens

Tab : 2 VARIATION OF THE ANTERIOR CEREBRAL ARTERY

S.no	TYPE OF VARIATION	No.
1	Larger vessel on the Left	1
2	Thin vessel on the Left	1
3	Larger vessel on the Right	1
4	Double branch on the Right	1
5	Single Anterior cerebral	1
6	Aneurysm on the Left	4
	Total	9

2.ABNORMAL PATTERN OF ANTERIOR COMMUNICATING ARTERY

Anterior communicating artery was having an oblique course in one specimen. It was absent in one(Fig1). There was a very short anterior communicating in one specimen. There was a double branching of the anterior communicating in one (Fig 2). In two of the specimens a plexiform arrangement was noted(Fig 3).

Tab 3: ABNORMAL PATTERN OF ANTERIOR COMMUNICATING ARTERY

S.no	TYPE OF VARIATION	No.
1	Oblique anterior communicating artery	1
2	Absent	1
3	Very short	1
4	Double anterior communicating artery	1
5	Double anterior communicating artery	2
	Total	6

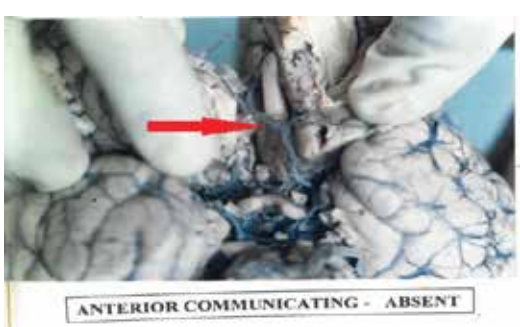

Fig. 1 Anterior Communicating Artery absent

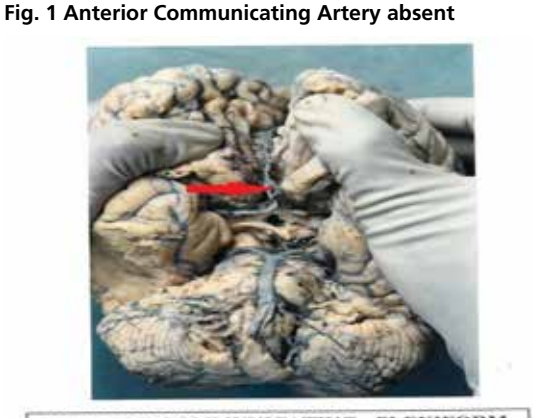

Fig. 2 Anterior Communicating – Double

Fig. 3 Anterior Communicating – Plexiform

3. ABNORMAL PATTERN OF POSTERIOR COMMUNICATING ARTERY

One specimen showed double branching of the posterior communicating(Fig 6). There was also absene of left posterior communicating in one specimen(Fig 5). There were two specimens with large posterior communicating on the right side and left side

Tab 4: ABNORMAL PATTERN OF POSTERIOR COMMUNICATING ARTER

S.no	TYPE OF VARIATION	No.
1	Left small size	1
2	Left short and thin (with accompanied thin anterior cerebral and larger anterior communicating)	1
3	Short and thin artery on the left	2
4	Absent left side	1
5	Double arterial branch on the left	1
6	Lef larger artery	1
7	Right larger artery	1
	total	8

Fig. 4 Multiple Anomalies – Right Posterior Communicating, Right Thin Proximal Sexments of Posterior Cerebral

Fig.5 Posterior Communicating – Left Absent

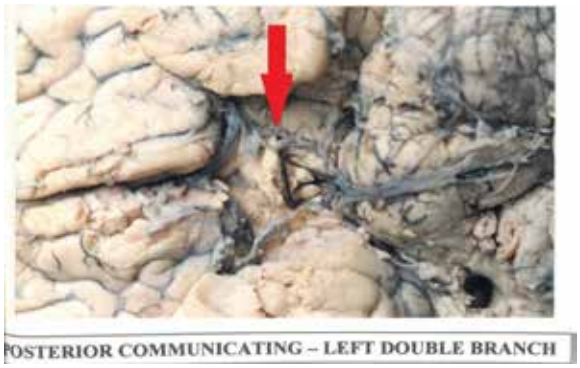

Fig. 6 Posterior Communicating – Left Double Branch

4.ABNORMAL PATTERN OF POSTERIOR CEREBRAL ARTERY

The Posterior cerebral arteryshowed a short vessel in one specimen on the left side and in one on the right side. A small sized vessel on the left in another specimen. There was a thin proximal segment of the posterior cerebral one on the left side and one on the right side(Fig 7). There was an aneurysm present one on each side of the right and left posteiror cerebral artery.

Tab 5: ABNORMAL PATTERN OF POSTERIOR CEREBRAL ARTERY

S.no	TYPE OF VARIATION	No.
1	Left short artery	1
2	Left thin artery	1
3	Right short artery	1
4	Left thin proximal segment	1
5	Right thin proximal segment	1
6	Aneurysm on the right side	1
7	Aneurysm on the left sidee	1
	total	7

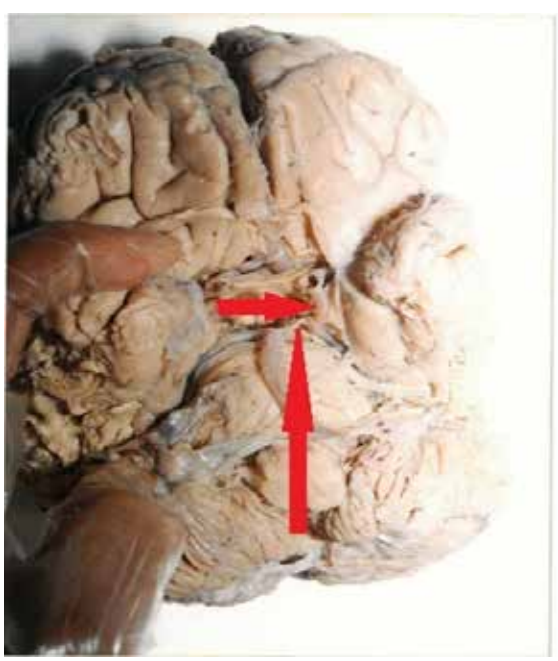

Fig. 7 Posterior Cerebral Left Thin Proximal Segment with Left Larger Posterior Communicating

Tab 6 SHOWING ABNORMAL PATTERN OF BASILAR ARTERY

S.no	FORMATION	No.
1	At the lower border of the pons	68
2	Below the medulla (low level formation	2

Fig. 8 Low Level Formation of Basilar Artery

Tab 7 ANEURYSM

S.no	ANEURYSM	No.
1	Anterior cerebral left	4
2	Posterior cerebral right	1
3	Posterior cerebral left	1

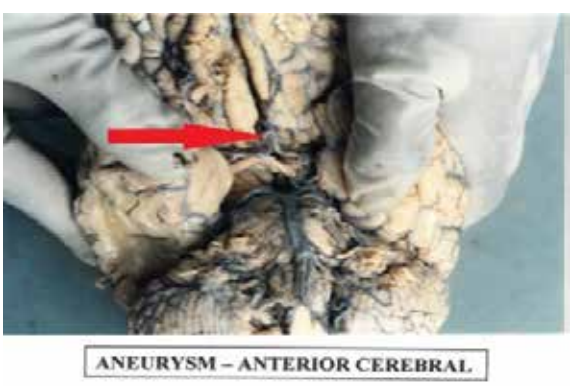

Fig. 9 Aneuysm –Anterior Cerebral

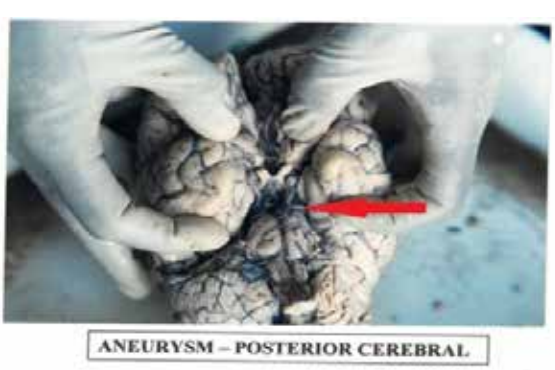

Fig. 10 Aneuysm – Posterior Cerebral

DISCUSSION

According to Gray the Circle of Willis (which is really more polygonal than circular) is situated in the cisterna Interpedun-

cularis at thebase of the brain and encloses the optic chiasma and the structures in the interpeduncular fossa and is formed in front by the two anterior cerebal arteries joined to each other by the anteiror communicating artery, behind the basilar artery divides into two posterior cerebral arteries each of which is joined to the internal carotid artery of the same side by the posterior communicating artery Robert B. Rutherford(1980)[11] stated that the Circle of Willis can be regarded as an arterial manifold that balances arterial flow from four principal sources - the two internal carotid arteries and the two vertebral.Injection of radio - opaque materials into the carotid artery of one side usually utline that carotid system only, very little passing into the other channel. He considered the Circle of Willis as an unique anastomotic arrangement that enables the anterior circulation to support the area of the posterior circulation in ase of proximal arterial compromise and vice versa. This incompleteness may be a cause of an inadequate collateral response when there is an occlusive compromise of either the anterior or posteriof circulation.In this present study there were absence of one anterior communicating artery and one left sided posterior communicating artery. Variations in the size of the vessels of the circle of willis is found in anterior cerebral, internal carotid, basilar and vertebral arteries. This study shows two absence of vessels out of 70 specimen giving the percentage of 2.86%, nearly corresponding to that of Faucett(1905)[6].

Large size anterior cerebrals are not mentioned in the available literature. According to B.A. Baldwin and F.R. Bell (1963) [2]this anamoly was found in 11.4%. The exact significance of large size anterior cerebral is not known. In his series it was observed that large size vessel supply a few branches to the opposite hemisphere. In this present study there were two large anterior cerebral were seen one on the left and the other on the right. The 2.86 percentage value of this study is not consistent with that of the study of P.C. Bansal

Basilar artery was found to be abnormal in size in a small percent of cases.In the present study the basilar artery was normal in size in all the cases. Low level fusion of vertebral arteries were noted in one case forming an elongated basilar artery.

Relatively common variation is a major or entire origin of posterior cerebral artery from the carotid by way of an enlarged posterior communicating artery. The occurrence of origin approximately 5% on the right side slightly less on the left and about 2% bilaterally but Sunderland (1943)[13]found a carotid origin of posterior cerebral bilaterally in 6% of 100 cases and unilaterally in about 13% each of right and left sides. Actually this origin represents a retention of the embryonic condition as the posterior cerebral is originally a branch of the internal carotid which subsequently transfers to the basilar. Berk and Alfar and Berry (1963)[1] have reported anomalous origin of posterior cerebrals in 14.5% and 15% of cases. P.C. Bansal's are more or less in accordance with those of Sunderland (1948) [13].In the present study the posterior cerebrals are all arising from the basilar artery. There were short posterior cerebral vessel one on each of the left and right side. On the left side one vessel was found to be thin and small. In two specimens the proximal segment of the posterior cerebral was thin one on the right side and one on the left side. Two aneurysms were noted one on each side.

The study of posterior communicating artery by Krishnakumar Bisaria (1984)[8] in 126 cranial cavities of adult cadavers revealed some hitherto unreported anomalies. These included the origin of one posterior communicating artery from the ophthalmic artery, inside the optic canal. The presence of 3 posterior on one side, the occurrence of 2 posterior cerebral arteries bring about possible normal circulation in cases involving obstruction to any one of them. The functional dilation of any other part of posterior communicating artery if perianeurysmal, may leak or rupture to produce subarchnoid haemorrhage. Pressure over the oculomotor nerve cause diplopia and on the optic chiasma and tracts may cause visual defects. In the present study the posterior communicating artery was absent in one case. One the left side of one brain there were two branches seen. Only one small vessel was noted on the left side. Shot and thin vessels were seen in three brains on the left side, of which one brain had associated thin Anterior cerebral and large Anterior communicating vessel. Two large vessels on on the right and one on the left were found.

The anterior cerrebral may be supplemented by a third or a so called middle anterior cerebral artery. Stopford found this in 6%, Blackburn in about 10%, Windle in a According to Bery (1961)[1] the proximal part of anterior cerebral artery atrophies or fails to develop to a string vessel.About 4.5% or one may be rarely absent or two may be united for a part or much of its course (Windle). Fusion of anterior cerebral arteries was present in 2% of human Circle of Willis examined by Alpar et al while in 96% of the specimens examined by Neal F Kassal. The morphological and functional importance of the distribution of the arteries receive a further significance from Blackburn's report on the abnormal median anterior cerebral artery as found among insane. They also added that the frequent variation of the system of vessels suggest instability of ontogeny and phylogeny. The incidence of triple anterior cerebral artery of corpus callosum is reported to be low. This artery develops as a median branch from the anterior communicating artery. It passes between the two anterior crebral arteries on the upper surface of the corpus callosum. Normally it atrophies but at time it may persist. In the pesent study there were two large vessels one on the right and one on the left. On the left side a thin vessel was noted. Right sided double Anterior cerebral was noted in one case. Single Anterior cerebral (Median cerebral artery) was noted in one. In four specimens there were left sided aneurysm.

The anterior communicating artery is occasioally but rarely absent, more often it is double 7 - 9% or even triple (Hollins Head). It is of course absent as a vessel when there is a fusion between the two anterior cerebral vessels. Berk and Stopford (1961)[3]have reported duplication of anterior communicating in 9% respectively. Cases of three arteries arising from the region of anteiror communicating artery was noted by M.E. Berk (1961)[3] which may be explained on the basis of the two normal anterior cerebral arteries with persistence of the modern artery of the corpus callosum.In the present studyof human brains a single median anterior cerebral artery was present in one case. In one case there was an anterior communicating artery which runs obliquely and forwards between the two anterior cerebral arteries. There was a double anterior communicating artery in one brain.In two cases both the Anterior cerebral arteries were connected by communicating arteries which had communications with one another so as to have a plexiform pattern. In one case a very short Anterior communicating artery was noted.

The Circle of Willis and its branches are of importance from the stand point of aneurysms. According to Dandy (1941) [10] more than half of all intracranial aneurysms arise from the Circle of Willis that about 80% of these aneurysms are congenital but Matas (1938)[10] expressed the belief that about 46% are of congenital origin Alpar and Berry (1963)[1] were of opinion that the aneurysms in the Circle of Willis occur in 22% of cases. P.C. Bansal et al in their series of dissections found that aneurysms occurring in another cerebral 6.9% posterior cerebral 1.1% and in the basilar artery about 2.3%. In the present work out of 70 human brains 4 cases of aneurysm occurring at the junction of anterior cerebral and anterior communicating artery on the left side was made out. One aneurysm was on the right posterior cerebral and one on the left posterior cerebral.

CONCLUSION

The variations of the circle of Willis play an important role in the occurrence, manifestation of symptoms, treatment options and recovery process of certain cerebrovascular disorders viz., stroke, and aneurysms. Variations were also found to be associated with migraine and mentally ill patients. The anomalies

encountered include absence of anterior & posterior communicating arteries, hypoplasia of the posterior communicating & posterior cerebral vessels, duplications of posterior communicating arteries, single anterior cerebral artery and low level formation of basilar artery. As it confirms high percentage of variations, all surgical interventions should be preceded by angiography. Awareness of these anatomical variations is important in neurovascular procedures and thorough knowledge of the vascular variants will increase the success of the procedure.

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