



MORPHOLOGICAL STUDY ON CIRCLE OF WILLIS-ANTERIOR CIRCULATION

Anatomy

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ABSTRACT

In the era of high technology and consumer litigations, the disease management has leaped to very high level to nanotechnology and further. As life span of individual human has increased, so are the disease pattern and its natural course. But human anatomy has very few deviations from its basic organogenesis. Identification of disease particularly of vascular origin and in particular of brain vascular pattern is very essential for the management. The present study was an attempt to find out the pattern of circle of Willis among South Indian population. Completeness of circle of Willis and anterior communicating artery as well as anomaly. we have examined 50 brain specimens. In the present study we noted that the normal circle was found only in 72% of brains examined. Among the 28% of variations, 6 were in anterior circulations. Among the 6 anterior circulation variation 1 anterior communicating artery was absent, 2 were slender and 1 had an oblique course and 1 was absent. The circle was incomplete in 6 specimens. In complete circles were associated with migraine aura subjects with controls and is associated with alteration in cerebral blood flow. Careful computed angiographic evaluation and an understanding of the vascular interrelationships in the circle of Willis are essential for a successful postoperative course, especially when very rare vascular anomalies treated.

KEYWORDS

Circle Of Willis, Anomaly, Anterior Communicating Artery, Morphology, Brain

1.INTRODUCTION:

Brain is a highly vascular organ. Its profuse blood supply is characterized by a densely branching arterial network. It has a high metabolic rate that shows the consumption of energy requirements of constant neural activity. It receives approximately 15% of the total cardiac output. It uses 25% of the total oxygen consumption of the body. The brain is supplied by 2 internal carotid arteries, 2 vertebral arteries that form a complex anastomosis (circle of Willis) on the base of the brain. Blood vessels diverge from this anastomosis to supply the various cerebral regions. In general internal carotid arteries, and the vessels arising from them supply the forebrain. Except of the occipital lobe of the cerebral hemisphere. The vertebral arteries and their branches supply the occipital lobe, the brain stem and the cerebellum. Venous blood from the brain drains into sinuses within the dura mater. Interruption of the blood supply to the brain for, more than a few minutes may cause permanent neurological injury. Such ischaemic damage along with intracranial haemorrhage is major contemporary sources of morbidity and mortality. The blood supply to the brain are derived from the internal carotid and vertebral system, which lie, together with their proximal branches, within the subarachnoid space. The internal carotids and their major branches (the internal carotid system or 'anterior' circulation) supply blood to the most of the forebrain. Some parts of the occipital and temporal lobes are supplied by branches given off by the vertebrobasilar system. The circulus arteriosus (circle of Willis) is a large arterial anastomosis which joins the internal carotid and vertebrobasilar systems. It lies in the subarachnoid space within the interpeduncular cistern, and surrounds the optic chiasma and infundibulum. Anteriorly, the anterior cerebral arteries, derived from the internal carotid arteries, are linked by the small anterior communicating artery. Posteriorly, the two posterior cerebral arteries, formed by the division of the basilar artery, are joined to the ipsilateral internal carotid artery by a posterior communicating artery. There is considerable change in the pattern and caliber of vessels that make up the circulus arteriosus. Although a complete circular channel almost always exists, one vessel is usually sufficiently narrowed to reduce its role as a collateral route and the circle is occasionally functionally complete. Cerebral and communicating arteries individually or collectively may all be not formed, not well developed, double or even triple variations. The hemodynamic of the circle of Willis, are influenced by many variations in the luminal caliber, of communicating arteries and in the segments of the anterior and posterior cerebral arteries. Which lie in between their origins and their junctions with the corresponding communicating arteries. The greatest change in caliber, between individuals vessels occurs, in the posterior communicating artery, which is normally very small, so that only limited blood flow is possible, between the anterior and posterior circulations. Commonly, the diameter of the pre communicating part of the posterior cerebral artery is larger, than that of the posterior

communicating artery, in which case the blood supply to the occipital lobes is, mainly from the vertebrobasilar system. However, sometimes the diameter of the pre communicating part of the posterior cerebral artery, is smaller than that of the posterior communicating artery, in which case the blood supply, to the occipital lobes is largely from the internal carotids via the posterior communicating arteries. Since the primary purpose of the vascular circle is, to provide anastomotic channels if one vessel is occluded. It is important to note that a normal-sized posterior communicating artery cannot fulfill this change. Agenesis or hypoplasia of the initial segment of the anterior cerebral artery, are more frequent, than anomalies in the anterior communicating artery and contribute to defective circulation, in about a third of individuals. Aneurysms are balloon-like bulge, which occur on arteries as a result of defects, in the layers of vessel wall. They are commonly found on the vessels of the circulus arteriosus, particularly at or near the junctions of vessels. Aneurysms on the internal carotid artery, near its termination may compress the lateral aspect of the optic chiasma. They compromise axons derived from the temporal side of the ipsilateral retina, which causes a defect in visual field. Aneurysms in the vicinity of the oculomotor nerve, e.g. on the posterior communicating artery, superior cerebellar artery, or the tip of the basilar artery, causes third nerve palsy by pressure effect. Bleeding into the subarachnoid compartment, subarachnoid haemorrhage, is the most common pathology, that involves the subarachnoid space. There are many causes; in adults the commonest is, rupture of an aneurysm of the intracranial vessels, that run within the subarachnoid space. A person who has had a subarachnoid haemorrhage, usually complains of a very sudden onset of headache, that is frequently described as being their 'worst ever headache'. When this is suspected, the first investigation is a CT examination which has a very high sensitivity, for detecting fresh haemorrhage. Blood will be seen in the basal cisterns and entering the depths of the cortical sulci, i.e. delineating the anatomy of the subarachnoid space, a presentation that permits an accurate diagnosis. In marked contrast, the spread of blood in a subdural haemorrhage, is limited by the arachnoid mater on its deep surface, and the blood therefore remains on the surface of the brain. Brain has a rich blood supply, which is supplied with blood through the confluence of vertebrobasilar and internal carotid system. The oxygen consumption of the neural tissue is very high (25% of the oxygen that is breathed in). Acute arrest of circulation produces loss of consciousness in about seven seconds. The cerebrovascular accidents (CVA) occurs due to infarction, hemorrhage and embolism result in stroke, in which the entire half of the body or a limb or one half of face is paralysed. In persons in whom there is narrowing of arteries they are more prone to stroke. The common causes of cerebral hemorrhage are aneurysm of major arteries, small arteriolar aneurysms due to hypertension and arteriovenous malformations. Therefore, the blood supply of the brain assumes a great importance. This arterial circle equalizes the pressure

of the brain flow to the two sides of the brain, as it is the main collateral channel. Variations are very common in the circle of Willis. Circle of Willis is the arterial arcade formed by the carotid system and verteobasilar system. It is polygonal in shape and is situated in the interpeduncular fossa. The knowledge of topography of blood supply of brain is very essential to identify the affected brain tissue, to localise any tumour, to perfuse medicine locally on the pathological area, to ligate the feeding vessel and to excise or remove the tissue or tumour.

2. AIM OF THE STUDY:

The present study was an attempt to find out the pattern of circle of Willis among South Indian population.

- In how many arterial circle of Willis were complete
- In how many brains the anterior communicating artery was complete and well developed or showed any variations.

3. MATERIALS AND METHODS

Fifty human brains of both sexes were collected for the present study from the Department of Forensic Medicine, Madurai Medical College, and Madurai 20. The age of the deceased from whom the brains were removed ranged from 24-75 years. All specimens were collected within two to eight hours after death. Brains were removed by detaching the falx cerebri from crista galli and the falx cerebri was pulled posteriorly from between the hemispheres. The head allowed to fall back. Olfactory bulb was visualized by elevating the frontal lobe and olfactory nerves were severed. Optic nerves were severed closely to optic foramen. Internal carotid arteries and the infundibulum of hypophysis were visualized and severed. The brain was allowed to fall backwards. Cerebral nerves were visualized. Lateral to the cerebellar free margins of tentorium cerebelli were observed and cut along the attachment. The brain was allowed to fall. All the nerves were identified. A knife is passed into the vertebral canal in front of medulla oblongata and a cut was made from side to side to sever two vertebral arteries and spinal medulla and the brain was delivered. The brain was washed with water to remove any blood stain. After clamping the internal carotid arteries a scalp vein set without needle was introduced into the basilar artery and tied to it. Normal saline was pushed through the scalp vein set using 50ml syringe. Following that 100ml of 10% formalin was injected. The scalp vein set was removed and the basilar artery was tied. The specimen was preserved in 10% formalin solution. 50 circulus arteriosus on the 10% formalin embalmed brains were studied. Duration of study period was 3 years in the dissection hall of Madurai Medical College, Madurai. The formation and branches of circulus arteriosus was observed by removing the arachnoid mater carefully, in the interpeduncular cistern. Posterior cerebral artery was traced from its origin to the termination, posterior communicating, anterior cerebral, anterior communicating, arteries was also observed. The variations encountered were noted. And the photography of the best observed anomalous circulus arteriosus was taken.

4. RESULTS:

The arterial circle or "Circle of Willis" is formed by anastomosis between the branches of internal carotid arteries and the basilar artery. It is located in the interpeduncular cistern at the base of the skull. The "Circle of Willis" or circulus arteriosus, has a great importance as the main brain collateral circulation specially in the old people who may have reduced brain blood supply due to senile arteriosclerosis. In normal condition, this circle is formed anteriorly by two anterior cerebral artery, right and left internal carotid and anterior communicating artery. Posteriorly on each side each internal carotid artery by its posterior branch, the posterior communicating artery, communicate with posterior cerebral artery, branch of basilar artery. The circle of Willis and the arterial branches which participate to make it show many variations, some of them may be hypoplastic or absent. The anterior communicating artery may frequently be double or even triple while the posterior communicating arteries seem to be more hypoplastic. A total of 50 specimens collected from the Department of Forensic Medicine, Madurai Medical College, Madurai -20, were examined for present study. They were classified according to age, In females it ranges from 28 years to 56 years. In males in ranges from 24 to 79 Sex among these 50 adult brains 35 were from male cadavers and 15 were from female cadavers. Internal carotid artery: In the fifty circle of Willis hundred internal carotid arteries were present both right and left side.

Anterior cerebral artery: Among the fifty specimens hundred anterior cerebral arteries were examined no abnormality was found in any of the specimen. **Anterior communicating artery:** Among the 50 specimens examined 1 anterior communicating artery was absent and it was present in 49 specimens among the 49 was specimens 44 were normal 5 were abnormal. The abnormality were double communicating were present in 1st and 6th specimen and 2 slender communicating was observed in 7th and 21st. One had oblique course and that was seen in 10th specimen, that was observed only in male specimens and no abnormalities of anterior communicating were found in female specimens



Figure No:1 Oblique Anterior Communicating Artery



Figure No:2 Slender Anterior communicating Artery

5. DISCUSSION & CONCLUSION

According to PP Poudel [1] and C Bhattarai [1] 2010, Nepal Med Coll Journal, "Circle of Willis" is a large arterial anastomotic ring of the brain, of the internal carotid and verteobasilar systems, lying in the subarachnoid space within the deep interpeduncular cistern. Anastomosis slows down the blood flow before it reaches the brain. It also helps in collateral circulation. The pulsations of the arteries also help in drainage of the cerebrospinal fluid. There were variations in the pattern and caliber of vessels in their study which make up the circulus arteriosus. Many times complete circular channel almost always exists, but occasionally one vessel is usually sufficiently narrowed as a collateral route. Cerebral and communicating arteries individually may all be absent, variable hypoplastic, double or even triple. The circle is rarely functionally complete. Anomalies of the branches can lead to conditions like stroke. The anomalies of the cerebral circulation, as they are not rare and may have profound clinical implications. Cerebral - vascular diseases present one of the leading problems. Which have the risk of high mortality and disability with people who survive cerebral - vascular incident (stroke, apoplexy). The knowledge of cerebrovascular variants is essential in education, training and treatment. In the present study of fifty human brains (male and female) collected from autopsy specimens from the Institute of Forensic Medicine, Madurai Medical College, Madurai -20, analysed for the pattern of circle of Willis along with the variations of contributing arteries also. Age of the specimens collected ranged from 24 - 79 in male & in females from 28 - 56. 15 from females and 35 from males were collected. Out of these 3 of female specimens and 11 of male specimens showed variations. There was no relationship with advancement of age and abnormalities observed in the present study. The pattern of abnormalities classified according to the sex found to be maximum in males and minimum in females. Circle of Willis: Normal pattern. In this study, of the 50 brain specimens observed 36 cases (72%) had normal anatomy of circle of Willis. Circle of Willis: Completeness of Arterial Circle. "Circle of Willis" is complete in 44 (88%) specimens and incomplete in 6 specimens (12%) in contrast to the study of Fawcett and Blachford 35 (3.9%) [2]. Thus the findings of the present study have a correlation with the findings of P N Jain and V Kumar (1990) [3] and Hartkamp et al [4] (1998) with respect to location of variations.

ANTERIOR CEREBRAL ARTERY In the present study hundred anterior cerebral arteries (fifty right and fifty left) were observed. In the present study hundred anterior cerebral arteries were found to be normal. Anbumani (1994) in his study of sixty human brains reported the anterior cerebral to be normal in 98.33%. In the present study the observation was 100%. Dolichoectasia of intracranial arteries is a rare arteriopathy characterized by elongation and widening of the arteries, mostly involving vertebral and basilar arteries. This report discusses large anterior communicating artery fenestration associated with posterior circulation anomalies. Kwak et al. [5] investigated arterial anomalies accompanying 296 cases of a single ACoA aneurysm and the etiological significance of these anomalies in the development of cerebral aneurysms. Either the ACoA fenestration or the presence of more than

two ACoAs was observed in 17 cases (5.7%). As the anomaly was duplicated in some of these cases, the total number of cases with ACoA anomalies resulted to be 26 cases (8.8%) out of 296 cases investigated. This occurrence rate was not higher than those observed in other previously reported cerebral aneurysmal cases and control cases. This present study correlates with respect to the duplications of anterior communicating artery. Anterior Communicating Artery: Oblique course. Oblique communication of anterior communicating artery was observed to be 2% in males specimens. Such observations made by Anbumani's series was found to be 1.66% in 60 cases. The present observations are more or less equal to the series of Anbumani. The oblique communications could be right to left or left to right which were classified from the lower side of commencement to the opposite side in an upward direction. Here it is right to left the correlation pattern though not observed in the Bergman series (2000) this classification was coined in the present study to denote the position and the angle of communication to the opposite anterior cerebral artery and this was considered as a worthwhile pattern of anomalies. The presence of Y shaped and V shaped communications were not found in present study. Thus, a higher incidence of absence of anterior communicating artery has been observed in the present study in comparison to the results of various other studies. The internal carotid arteries were examined it was to be present in all the 50 specimens. The anterior communicating arteries were examined. In 49 specimens these were present and in one specimen it was absent. The 49 anterior communicating arteries were classified into (i) double anterior communicating, (ii) slender anterior communicating (iii) oblique (iv) absence. The anterior cerebral arteries were examined it took origin from the upturned stem portion of internal carotid artery. Two arteries on each side took origin from the anterior aspect of the stem. On examining the anterior cerebral arteries all the hundred arteries were present and no abnormalities were noted. On examining the posterior communicating arteries, seven specimens showed abnormalities were reclassified into (i) slender, (ii) plexiform (iii) absence. We have examined 50 brain specimens. In the present study we noted that the normal circle was found only in 72% of brains examined. Among the 28% of variations, 6 were in anterior circulations. Among the 6 anterior circulation variations 1 anterior communicating artery was absent, 2 were slender and 1 had an oblique course and 1 was absent. The circle was incomplete in 6 specimens. Incomplete circles were associated with migraine aura subjects with controls and is associated with alteration in cerebral blood flow. Careful computed angiographic evaluation and an understanding of the vascular interrelationships in the circle of Willis are essential for a successful postoperative course, especially when very rare vascular anomalies are treated.

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