Anatomy & Physiology: Current Research

Sawanth and Rizvi, Anat Physiol 2017, 7:3
DOI: 10.4172/2161-0940.1000264

Research Article OMICS International

Study of Variant Posterior Cerebral Circulation and its Clinical Relevance

Sawant SP* **and Rizvi S**

Department of Anatomy, KJ Somaiya Medical College, Somaiya Ayurvihar, Eastern Express Highway, Sion, Mumbai, India

***Corresponding author:** Sawanth SP, Department of Anatomy, KJ Somaiya Medical College, Somaiya Ayurvihar, Eastern Express Highway, Sion, Mumbai, India, Tel: +9322061220; E-mail: drspsawant@gmail.com

Received Date: April 24, 2017; **Accepted Date:** May 03, 2017; **Published Date:** May 10, 2017

Abstract

The cerebral blood flow is divided into an anterior circulation and a posterior circulation connected to each other in the form of a circle called Circle of Willis (CW). It is formed by the unification of the internal carotid (ICA) and vertebrobasilar systems Posteriorly, the basilar artery, formed by the left and right vertebral arteries, branches into a left and right posterior cerebral artery (PCA), forming the posterior circulation. The internal carotid system lies anteriorly and is joined to the posterior circulation by posterior communicating (PCoA) arteries. The internal carotid artery divides into anterior and middle cerebral artery. The two anterior cerebral arteries are joined to each other by an anterior communicating artery. The posterior cerebral artery before it joins the posterior communicating artery that means its proximal part is named as the pre communicating part (P1) and the distal part as the post communicating part (P2). In the adult P1 has a diameter larger than the PCoA so that the occipital lobe gets its blood supply mainly via the vertebrobasilar system whereas in the fetus the diameter of the ipsilateral precommunicating (P1) segment of PCA is less than the diameter of PCoA, so that the blood supply to [1] the occipital lobe is mainly via the internal carotid arteries. In some persons, there is a transitional configuration in which the PCoA is equal in diameter to the P1 segment of the PCA. These variations can cause complications if thrombotic material present in atherosclerotic plaques of ICA gets dislodged into PCA through a PCoA which has a larger diameter.

In the present study, the configuration of posterior cerebral circulation and its clinical relevance was studied in 40 human brains in the department of anatomy at KJSMC. Adult Type PCA was found in 60% of the specimens studied, Fetal Type PCA was found in 12.5% of the specimens, Transitional Type PCA was found in 25% of the specimens and a combination of Adult and Transitional Type was found in 2.5% of the specimens.

Keywords: Brain; Cerebral; Arteries

Introduction

The cerebral blood flow is divided into an anterior circulation and a posterior circulation connected to each other in the form of a circle called Circle of Willis (CW). It is also known as Willis Polygon after its discovery by Thomas Willis [1]. It is formed by the unification of the internal carotid and vertebrobasilar systems Posteriorly, the basilar artery, formed by the left and right vertebral arteries, branches into a left and right posterior cerebral artery (PCA), forming the posterior circulation. The internal carotid system lies anteriorly and is joined to the posterior circulation by posterior communicating arteries. The internal carotid artery divides into anterior and middle cerebral artery. The two anterior cerebral arteries are joined to each other by an anterior communicating artery. The posterior cerebral artery before it joins the posterior communicating artery, that means its proximal part is named as the pre communicating part (P1) and the distal part as the post communicating part (P2) [2]. The cortical branches of PCA supply blood to the occipital lobe, the inferomedial temporal lobe, and portions of the posterior inferior parietal lobe. Communicating arteries reroute the blood if some artery has developed a diminished blood flow [3]. In the adult P1 has a diameter larger than the PCoA so that the occipital lobe gets its blood supply mainly via the vertebrobasilar system whereas in the fetus the diameter of the ipsilateral precommunicating (P1) segment of PCA is less than the diameter of PCoA, so that the blood supply to the occipital lobe is mainly via the internal carotid arteries. In some persons, there is a transitional configuration in which the PCoA is equal in diameter to the P1 segment of the PCA. Thus three basic configurations of the PCA have been described; fetal, transitional and adult. These variations can cause complications if thrombotic material present in atherosclerotic plaques of ICA gets dislodged into PCA through a PCoA which has a larger diameter [4].

Brain is a highly vascular organ and obtains 15% blood supply. The Circle of Willis plays a chief role in sustaining a steady blood flow to the cerebrum. The continuance of a steady blood flow through the Circle of Willis is important to curtail the occurrences of cerebral infarcts and also to preserve perfusion during cardiac surgeries with extracorporeal circulation [5]. The Circle of Willis acts as a closed space in which fluid starts its circulation from one entry point and returns to it. The branches of the Circle of Willis act as end arteries once they enter the cerebral hemisphere, and no additional anastomosis is possible. Thus collateral circulation is completely dependent on the calibre of the branches of the Circle of Willis [6].

Aim

To study the configuration of posterior cerebral circulation in 50 human brains.

Materials and Methods

The present study was carried out in the department of anatomy at KJSMC, from July 2012 to August 2016. It included 50 human brains (40 males and 10 females) irrespective of the cause of death. Brains were obtained from cadavers donated to the Dissection hall of the Department of Anatomy. After excising the vaults, dural folds were cut and brains were detached carefully from the cranial cavity with their arteries intact. They were washed under running water and their ventral surfaces were cleared. The Circle of Willis and its branches were completely cleared and exposed. Their formative pattern was observed. The external diameters of posterior cerebral and posterior communicating artery were seen with vernier calipers at 2 different points Data obtained were tabulated. The noted variations were photographed.

Results

Out of the 50 specimens examined, 30 circles showed bilateral Adult type PCA in which Rt and Lt PCA were of normal measurement and diameter of PCA was more than PCoA. Similarly 5 circles showed bilateral Foetal type PCA in which PCoA arteries of right and left side were normal but diameter of PCoA was more than PCA. 15 circles showed bilateral Transitional type PCA in which diameter of PCA and PCoA were equal. One specimen showed adult plus transitional type PCA, Right side showed transitional Type PCA and left side showed Adult type PCA.

Figure 1: Showing normal circle of willis and its diagrammatic representation.

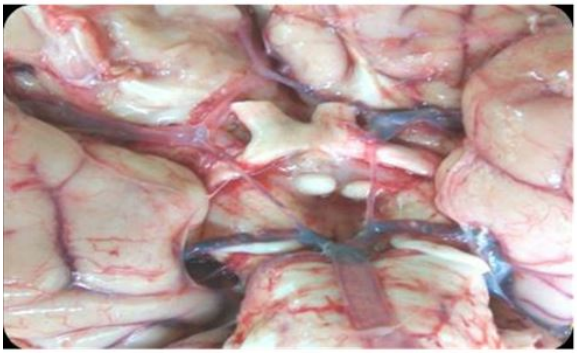

Figure 2: Showing adult type PCA PCA ≥ PCoA-30 [60%].

Figure 3: Showing foetal type PCA PCoA ≥ PCA-5 [10%].

Figure 4: Showing transitional type PCA PCA=PCoA-15 [30%].

Figure 5: Showing adult+transitional type PCA-1 [2%].

Discussion

Some authors believe that anatomical variation in the Circle of Willis is intimately linked to blood flow in brain feeding arteries. Hollinshead has mentioned that variations in the vertebrals or basilar or their branches are a rule rather than an exception and variations in the sizes of the vessels participating in Circle of Willis are also very common [7]. Non-classic morphology is more frequently established in the posterior circulation and most brains have bilateral posterior

alterations. The most frequent defect in Circle of Willis is absence of one or more PCoA followed by major entire origin of PCA by way of an enlarged PCoA [8].

In the present study 60% showed adult-type PCA which is closely comparable with previous studies. Comprehensive information regarding arterial supply may be helpful in perceiving alterations in the vessel due to pathology, in treatment of vascular lesions and in planning of neurosurgical and vascular interventions including aneurysm [9]. In one study of 35 Circle of Willis, variations were found in 3 cases (8.6%). The precommunicating branch of PCA was larger than PCoA and all the variants were found bilaterally [10].

If the anterior circulation, is compromised, the posterior circulation supplies the anterior circulation via the collaterals thus preventing an occlusive cerebro vascular disease In fetal type PCA when the P1 segment still has not developed, the posterior cerebral arteries (PCAs) are still supplied by the internal carotid arteries (ICAs) through posterior communicating arteries (PCoAs) [11].

Krabbe-Hartkamp [12] and Jain [13] have reported fetal type of PCA in 32% and 16.66% of their specimens respectively. An anatomic variant of the PCA, known as fetal type or fetal PCA (FPCA), has been identified by anatomic and angiographic studies in 11% to 46% of adult humans [14], fetal configuration of PCA was seen in 10% in the present study. In complete fetal-type PCA, the prospect of a collateral circulation developing between anterior and posterior cerebral circulation is impossible as PCA flow is totally dependent on the ICA and this can be responsible for a stroke. The incidence of the adult configuration was highest in the present study as compared to other studies [15].

Embryological Basis

Internal carotid artery develops from the 3rd aortic arch at 4th week of IUL and divides into anterior and posterior branches. The anterior branch gives rise to anterior and middle cerebral arteries. Vertebral arteries develop from longitudinal postcostal anastomosis of intersegmental arteries. They later join to form basilar artery which takes over the blood supply of the hindbrain and the brainstem thus reducing the calibre of posterior division of internal carotid artery. This then persists as posterior communicating artery [16]. A posterior division of posterior cerebral artery links up with the respective longitudinal artery of hind brain. After the formation of anterior cerebral arteries on both sides, an arterial network develops between two arteries which later develop into single anterior communicating artery. Circle of Willis is completely developed by 6-7 weeks. Disappearance of vessels that normally persist and persistence of vessels that normally disappear or formations of new vessels can be attributed to hemodynamic factors. This could be the probable reason for anomalies [17].

Clinical Significance

Study of variation in the cerebral circulation is vital to neurosurgeons to consider the possibility of shunt operations and in selection of patients for the same. The knowledge of this variation is very important during surgical and radiological inter- ventions. Circle of Willis is of paramount significance in aged population to maintain collateral circulation, as they suffer from senile arteriosclerosis. It is also extremely important in cerebrovascular accidents, the clinical manifestations of which reveal the region perfused [18]. Researchers have established that if there is an insufficient collateral blood flow made available by the Circle of Willis there is more probability of a stroke if the stream is rerouted to one area, then other areas may have to endure with less flow resulting in hypo perfusion and eventually ischemia. This 'steal phenomenon' is common in the cerebral circulation [19,20].

Conclusion

The collateral blood flow in the cerebrum is dependent upon the pattern and calibre of the branches forming the Circle of Willis and is best tested in times of an emergency Study of variation in the cerebral circulation is vital to neurosurgeons to consider the possibility of shunt operations, in aged population to maintain collateral circulation, as they suffer from senile arteriosclerosis and also extremely important in cerebrovascular accidents. Anomalies of the PCoA have a great significance since it forms a link between two major arterial systems the internal carotid and the vertebrobasilar circuit.

Acknowledgement

Authors are thankful to Sabnis V for his support and encouragement. Authors are also thankful to Murugan M, Kadam P, Dalvi S, Rangle K, Adkhale S, Shinde S, Beradiya K and Panduj for their help. Authors also acknowledge the immense help received from the scholars whose articles are cited and included in references of this manuscript. The authors are also grateful to authors, editors and publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed.

Statement of Human and Animal Rights

All procedures performed in human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

References

1. Lynn R, Chebl AA (2009) Cerebral arterial anatomy. Practical carotid artery stenting pp: 63-74.
2. Cagatay (2004) Thomas WillisÕ Famous Eponym: The Circle of Willis. Turk J Med Sci 34: 271-274.
3. Pai BS, Varma RJ, Nirmala S, Manjunath LC, Rakshith S (2007) Microsurgical anatomy of the posterior circulation. Neurol 55: 31-41
4. Trushel NA, Pivchenko PG, Mel'nikov IA (2012) Structural peculiarities of the wall of the vessels of the cerebral arterial circle in the area of bifurcations in people of different age. Morfologiia 142: 39-43.
5. Pedroza A, Dujovny M, Artero JC, Umansky F, Berman SK, et al. (1987) Microanatomy of the posterior communicating artery. Neurosurgery 20: 228-235.
6. Riggs HE, Rupp C (1963) Variation in form of the circle of Willis. The relation of the variations to collateral circulation. Anatomic analysis Arch neuro 8: 8-14.
7. Hollinshead WH (1968) The Cranium: Blood supply of brain. Anatomy for Surgeons 12: 37-46.
8. Alpers BJ, Berry RG, Paddison RM (1959) Anatomical studies of the CoW in normal brain. Arch Neurol Psychiatry 81: 409-418.
9. Silva KRD, Silva TRN, Amaratunga D, Gunasekera WSL, Jayesekera RW (2011) Types of the cerebral arterial circle (circle of Willis) in a Sri Lankan Population. Neurol 11: 1-8.

10. Sahani D, Jit I, Vivek L (2007) Variation and anamolies of the posterior communicating artery in northwest Indian brains. Surgical neurology 12: 449-453.
11. Pedroza A, Dujovny M, Artero JC, Umansky F, Berman SK, et al. (1987) Microanatomy of the posterior communicating artery. Neurosurgery 20: 228-235.
12. Hartkamp MJ, Grond J, Leeuw FE, Groot JC, Algra A (1998) Circle of Willis, Morphologic variation on three dimensional time-of-flight MR-angiograms. Radiology 207: 103-111.
13. Jain PN, Kumar V, Thomas RJ (1990) Anomalies of human cerebral arterial circle (of Willis). IJAV 39: 137-146.
14. Nayak S, Somayaji SN, Saumya KV (2008) Variant arteries at the base of the brain; International Journal of Anatomical Variation 20: 60-61.
15. Raamt A, Williem PTM, Van J, GraafaV (2006) The Fetal Variant of the Circle of Willis and Its Influence on the Cerebral Collateral Circulation. Cerebrovasc Dis 22: 217-224.
16. Padget DH (1948) The development of the cranial arteries in the human embryo, Contrib Embryol 32: 205.
17. Bullen F (1980) Absence of one anterior cerebral with both coming from opposite carotid. J Ment Sci 36: 32.
18. Kinkel WR, Newman RP, Jacobs L (1984) Posterior cerebral artery branch occlusions: CT and anatomic considerations. Vertebrobasilar Arterial Occlusive Disease 117-133.
19. Chuang YM, Liu CY, Pan PJ (2008) Posterior communicating artery hypoplasia as a risk factor for acute ischemic stroke in the absence of carotid artery occlusion. J Clin Neurosci 15: 1376-1381.
20. Routsonis K,StamboulisEl, Christodoulaki M (1973) Anomalies of the circle of Willis and atherosclerosis. Vascular and Endovascular Surgery 7: 141-145.