

Variations in the configuration of the posterior cerebral circulation in the adult human cadavers

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Abstract

Introduction: The knowledge on the incidence of the different configurations of posterior cerebral circulation of brain is of great value to the neurosurgeons while dealing with the cerebrovascular diseases as the fetal configuration and other variations such as absence or hypoplasia of posterior communicating artery or hypoplasia of posterior cerebral artery may lead to ischemia of posterior part of the brain. As the posterior cerebral vessels have a significant clinical importance, the present research was carried out on the incidence of different configurations and variations of posterior cerebral circulation.

Materials and Method: The present study comprised of 40 adult human brains consisting of 30 male and 10 female. In all the brains, the circle of Willis's was observed to note the variations and the type of configurations of posterior cerebral circulation.

Results: The posterior cerebral circulation was observed as the adult, fetal and transitional configurations and the incidence were 57.5%, 18.75%, and 1.25% respectively. The posterior communicating artery was absent in 22.5%. The presence of additional hypoplastic vessel connecting the posterior communicating artery and the posterior cerebral artery was observed in 2.5%.

Conclusion: The knowledge on the variations and the incidence of the different configurations of posterior cerebral circulation would be helpful to the neurovascular surgeons while dealing with the cerebrovascular diseases.

Keywords: Posterior cerebral circulation, Circle of Willis's, Circulus Arteriosus, Posterior cerebral artery, Posterior communicating artery, Brain

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Introduction

Circle of Willis's or circulus arteriosus is an arterial ring formed by the anastomosis of internal carotid and vertebrobasilar arterial systems. The posterior cerebral circulation is chiefly formed by a pair of Posterior Communicating Arteries (PCoA) which are the branches of the internal carotid arteries. After its origin, they run backward and anastomose with the posterior cerebral artery (PCA) of their respective side to close the arterial circle and complete the Circulus Arteriosus. The vertebral arteries join to form the basilar artery. After its formation, it runs upwards and terminates by giving two posterior cerebral arteries at the points-medullary junction.⁽¹⁾ The arterial circle is normally symmetrical with a complete ring of arteries around the interpeduncular fossa. Variations in the typical configuration of these posterior cerebral vessels may vary in caliber which may be absent, hypoplastic, or even duplicated.⁽²⁾

The development of the blood vessels supplying to the brain starts at the stage of 1.3mm size embryo when the six pairs of primitive pharyngeal arch arteries develop and eventually undergoing heavy modifications during development. The formation of the posterior cerebral circulation begins at the 4-5mm size of the embryonic stage where the hindbrain is supplied by two parallel neural arteries which gets their blood supply from the carotid and vertebra-basilar arterial

anastomoses provided by the trigeminal artery which is formed by the otic artery, the hypoglossal artery, and the proatlantal artery. At 5-8mm embryonic stage the basilar artery formation takes place by the consolidation of the neural arteries and within a week the PCoA develops and connects with the distal part of basilar artery followed by the regression of the trigeminal artery, otic artery, and hypoglossal artery, but the proatlantal artery persist until the complete development of vertebral arteries. The multiple events occurs during the developmental process of the blood vessels of brain lead to diverse spectrum of vascular anatomical variations.⁽³⁾

The three basic configurations of posterior circulation of the brain were the fetal configuration, transitional configuration, and the adult configuration. In the fetal configuration, the blood supply of occipital lobe of the brain is chiefly supplied by the internal carotid artery as the PCoA is larger than the PCA. In the transitional type of configuration, the blood is supplied to the occipital lobe equally by both the internal carotid and vertebrobasilar systems where the PCoA and PCA are equal in their size. In the adult configuration of the posterior cerebral circulation, the occipital lobe of the brain is predominantly supplied by the vertebrobasilar system where the PCA are bigger than the PCoA.⁽⁴⁾ The fetal configuration has clinical importance as a thrombus may pass through the internal carotid artery can dislodge and enter into the PCA and cause the cerebrovascular

stroke by blocking the PCA and its branches.⁽⁵⁾ The present research was focused on the incidence of different configurations and variations of posterior cerebral circulation and the variations of the PCA and PCoA which would be helpful for the neurovascular surgeons while dealing with the clinical and surgical procedures of this region.

Materials and Method

The study sample was consisting of 40 embalmed brain specimens. Out of 40 specimens, 30 specimens were of the adult males and remaining 10 specimens were of the adult female. These brain specimens were obtained from the formalin fixed cadavers during routine academic dissection. All the collected specimens were stored in 10% formalin after removing from the cadaver and numbered. The dura mater and arachnoid maters were removed to visualize the circle of Willis. Brain with pathology, trauma, and damage along with its supplying blood vessels which affect the topography of the arteries had been excluded from the study. The posterior cerebral circulation was observed for any variations in the origin, course, length and diameter and the absence of component vessel of PCA, PCoA and the basilar artery (BA). The posterior circulation was classified as adult type, fetal type, and transitional type. The incidence of each type was noted and the photographs were taken.

The vessel with a diameter of less than 1 mm has been described as hypoplastic vessels.

Results

In 40 skulls a total of 80 sides (40 right & 40 left) were observed. Among that 12 specimens bilaterally, 6 unilateral right and 14 unilateral left were presented with the adult type of configuration. Thus 57.5% was reported as bearing adult configuration. Fetal configuration was observed bilaterally in 1 specimen (Fig. 1a), right unilaterally in 9 specimens (Fig. 1b) and left unilaterally in 6 specimens (Fig. 1c). Thus fetal configuration was observed in 18.75%. The transitional configuration was observed in a specimen on its right side only. Thus the incidence was 1.25% (Fig. 2). Apart from the types, some other variations were also observed. They were the complete absence of PCoA and a hypoplastic additional vessel connecting the PCoA and PCA. PCoA was absent bilaterally in 5 specimens (Fig. 3a), right unilaterally in 6 specimens (Fig. 3b) and left unilaterally in 2 specimens (Fig. 3c). Thus the incidence of the absence of posterior CoA was reported as 22.5% sides. The incidence of the various configurations of posterior cerebral circulation was tabulated in Table 1. The incidence of the presence of additional hypoplastic vessel connecting PCoA and PCA was 2.5% (Fig. 4 & 5).

Table 1: Showing the incidence of the different types of the posterior cerebral circulation

Type/ Side	Adult type	Fetal type	Transitional type	PCoA absent
Bilateral	12	01	0	05
Right	07	08	01	06
Left	15	05	0	02
Total	46	15	01	18
Percentage	57.5%	18.75%	1.25%	22.5%

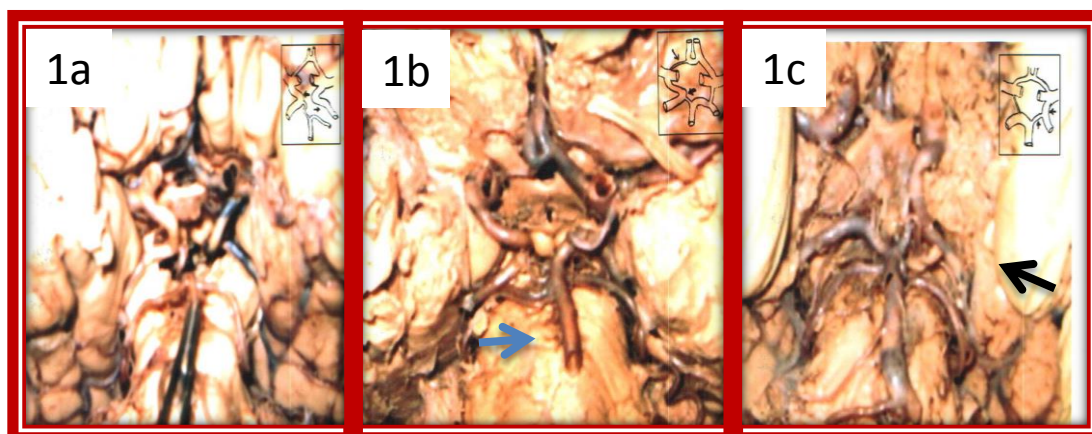


Fig. 1: Showing the bilateral (1a), right unilateral (1b), left unilateral (1c) fetal configuration of the posterior cerebral circulation

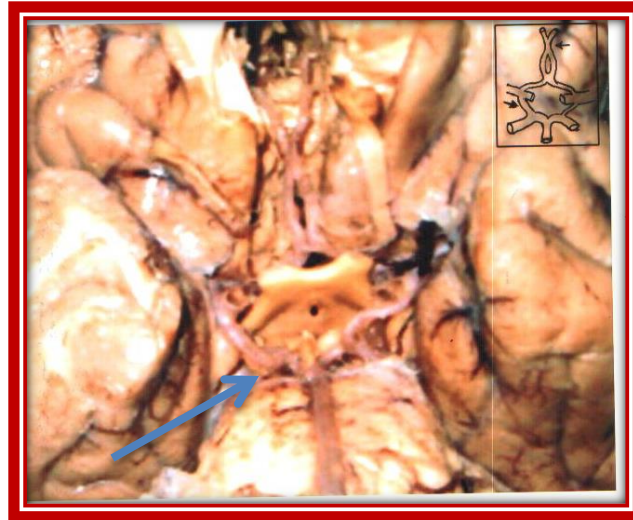


Fig. 2: Showing the right unilateral transitional configuration of the posterior cerebral circulation

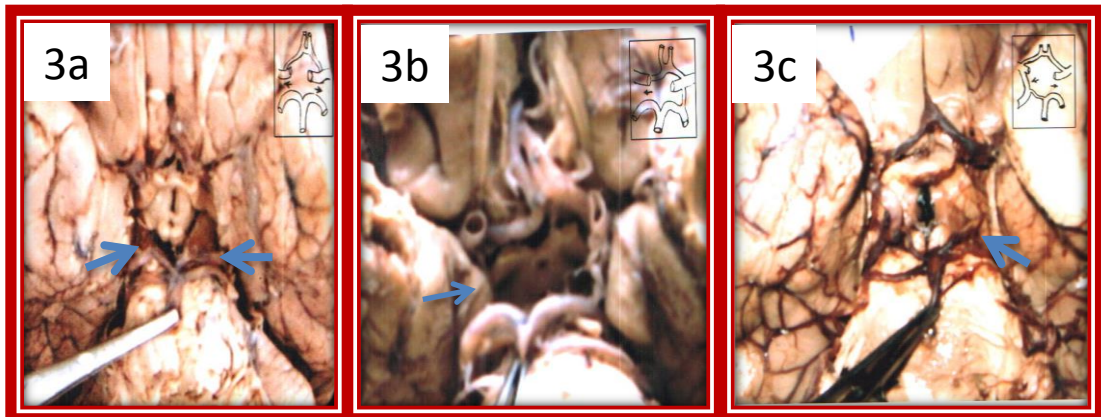


Fig. 3: Showing the bilateral absence of PCoA (3a), right unilateral (3b), left unilateral (3c) absence of PCoA



Fig. 4: Showing a hypoplastic vessel connecting the PCA and PCoA on its right side

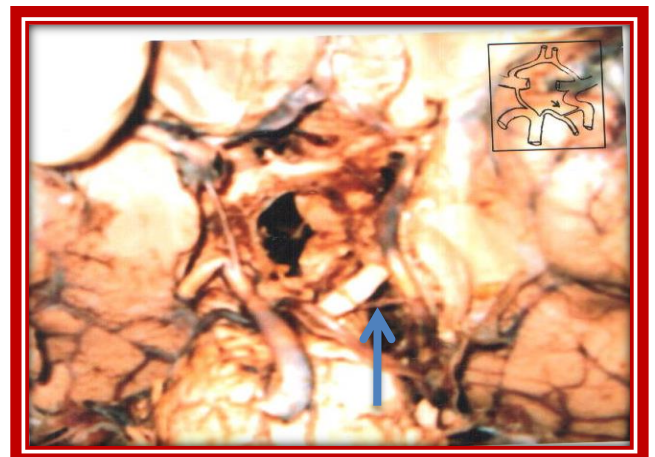


Fig. 5: Showing a hypoplastic vessel connecting the PCA and PCoA on its left side

Discussion

Cerebrovascular strokes are mainly due to the atherosclerosis affecting the cerebral vessels that supply the brain.⁽⁶⁻⁹⁾ Hypertension, diabetes mellitus, hypercholesterolemia and smoking are associated with

atherosclerosis which are considered as the most common and traditional risk factors.⁽¹⁰⁻¹³⁾ The geometric patterns of blood flow and the differential shear stress in the arterial wall are important determinants of the localization of atherosclerosis.⁽¹⁴⁻¹⁶⁾ As the blood vessels of the brain are clinically important, the present study was carried out on the variations of the posterior cerebral circulation and the incidence of different configurations of the posterior cerebral circulation.

The adult configuration in the present study was 57.5% which is much lower than the other studies by Kamath et al., A Prasanna et al., De Silva et al., and J J Overbeeke et al., where it was 73.5%, 80%, 93.3%, and 84% respectively.^(1,4,5,17) Thus percentage of variations observed in the present study was higher than the other

studies. The incidence of occurrence of the fetal configuration of the posterior circular was reported as 25% and 13.3% in other Indian studies by Kamath et al., and A Prasanna et al respectively. In the present study, the incidence was reported as 18.75% which was within the range of these two studies.^(1,17) De Silva et al., reported the incidence as 4.4% in Sri Lanka population which was much lower than the present study.⁽⁵⁾ The incidence of the transitional configuration was 1.25% in the present study was similar to the other studies by Kamath et al., De Silva et al., and J J Overbeeke et al where they reported as 1.5%, 2.2%, and 2% respectively. A Prasanna et al., reported the incidence of transitional configuration as 6.75 which was little higher than the present study (Table 2).^(1,4,5,17)

Table 2: Comparison of the incidence of occurrence of the different configurations of the posterior cerebral circulation

Author/ Configuration	Adult configuration	Fetal configuration	Transitional configuration
Kamath et al ⁽¹⁾ .,	73.55%	25%	1.5%
A Prasanna et al ⁽¹⁷⁾ .,	80%	13.3%	6.75%
De Silva et al ⁽⁵⁾ .,	93.3%	4.4%	2.2%
J J Overbeeke et al ⁽⁴⁾ .,	84%	14%	2%
The present study	57.5%	18.75%	1.25%

The incidence of the absence of PCoA in the present study was reported as 12.5% bilaterally, 15% right unilaterally and 10% left unilaterally which was similar to Anubha Shah et al., where it was 16.6%, 13.3%, and 8.3% respectively.⁽¹⁸⁾ The presence of the PCoA is very important for effective collateral circulation. The absence of PCoA impairs collateral circulation because of an incomplete circle of Willis. As the study reports the higher percentage of variations in blood vessels of the posterior cerebral circulation, all surgical procedures should be planned after confirming by angiography.⁽¹⁹⁾

Conclusion

The incidence of variations reported in the present research study was higher than the other studies. As the variations are more the impairment of collateral circulation is also increased which would be causing the increased risk of cerebrovascular diseases. Thus the anatomical knowledge on the morphological variations and the contribution in the formation of posterior cerebral circulation would be of great value to the neurovascular surgeons while dealing the cerebrovascular diseases.

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