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Original Research Article

Observation on Origin Course and Branching Pattern of Posterior Cerebral Artery in Human Brain

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Abstract:

Background and Objectives: The brain is an organ that serves as the centre of nervous system. It is the master regulator of the whole body function containing about 15-33 billion neurons. This regulating function of the brain on the rest of the body allows rapid and coordinated responses to changes in the environment. As the artery supplies very important areas of the central nervous system, it becomes important to know the variations in the artery. To facilitate better understanding of pathogenesis of various diseases involving posterior cerebral artery perfused regions of brain.

Materials and Methods: The present study was done in 20 posterior cerebral arteries (20 cerebral hemispheres) in the department of Anatomy. The present work entitled "Observations on origin, course and branching pattern of posterior cerebral artery in human brain" was carried out in Department of Anatomy, PMCH, Patna.

Conclusion: In all the 10 brains the posterior cerebral artery (PCA) was present on either side, arising from the basilar bifurcation. In one brain fetal configuration of PCA origin was seen on left side in which the posterior communicating artery was visible to be much thicker than the P1 segment of PCA.

Keywords: PCA, P1 Segment, Posterior Cerebral Arteries.

Introduction

The brain is an organ that serves as the centre of nervous system. It is the master regulator of the whole body function containing about 15-33 billion neurons. This regulating function of the brain on the rest of the body allows rapid and coordinated responses to changes in the environment. The anatomy and physiology of the brain are complex and essential to sustain life.

Many complex functions are directly or indirectly controlled by the brain like planning and initiation of voluntary movements, behavior, memory, sensory and motor functions, hearing, vision and regulation of all visceral functions. Despite all the exhaustive studies in brain till date, there is still much more room to explore. The brain receives blood from two sources: internal carotid arteries, which arise in the neck where the common carotid arteries bifurcate, and the vertebral arteries [1].

The internal carotid artery begins in the neck as one of the terminal branch of common carotid artery at the level of upper border of thyroid cartilage. It courses through the neck within the carotid sheath, and then enters the skull in Petrous part of the temporal bone through carotid canal. It then runs forward through the cavernous sinus, lying in the carotid groove on the side of the body of the sphenoid bone. The internal carotid arteries finally end below the anterior perforated substance by dividing into two major cerebral arteries, the anterior and the middle cerebral arteries. The right and the left vertebral arteries, branches of first part of subclavian artery, come together at the level of pons on the ventral surface of the brain stem to form the midline basilar artery. [2]The basilar artery joins the internal carotids in an arterial ring at the base of the brain (in the vicinity of the hypothalamus and cerebral peduncles) called the circle of Willis2. The posterior cerebral artery arises as the terminal branch of basilar artery. The two small bridging arteries, the anterior and the posterior communicating arteries join the two major sources of cerebral vascular supply. They presumably improves the chances of any region of the brain continuing to receive blood even if one of the major arteries becomes occluded as seen in the case thrombosis of one anterior cerebral artery which remains asymptomatic due to the flow from contralateral anterior cerebral artery through anterior communicating artery [3].(Standring S,2001)

The posterior cerebral artery is the terminal branch of basilar artery. It curves laterally over the crus cerebri of midbrain, parallel to superior cerebellar artery but separated from it by third and fourth cranial nerves. After being joined by the posterior communicating artery, it passes to the tentorial part of the inferior surface of the cerebrum. Posterior cerebral artery supplies the occipital lobes and the posteromedial temporal lobes. With the advances in micro-neurosurgery and radiology and a more effective ability to tackle diseases of the intracranial arteries; accurate knowledge of the intracranial vascular anatomy is becoming increasingly important.

There is paucity of data in existing literature regarding variations in origin, course & branching patterns of posterior cerebral artery. An enhanced description of anatomy & variations of posterior cerebral artery will contribute towards better understanding of vascular pathologies, thereby improving therapeutic interventions. With increasing availability of improved imaging facilities and revascularization interventions, the need for detailed understanding of anatomical aspects of posterior cerebral artery cannot be overstressed. This study acknowledges this need to add to the existing understanding and literature regarding the detailed anatomy of posterior cerebral artery and strives to make a small contribution towards this end [4].

Objectives

As the artery supplies very important areas of the central nervous system, it becomes important to know the variations in the artery.

To facilitate better understanding of pathogenesis of various diseases involving posterior cerebral artery perfused regions of brain.

Materials and methods

The present study was done in 20 posterior cerebral arteries (20 cerebral hemispheres) in the department of Anatomy. The present work entitled "Observations on origin, course and branching pattern of posterior cerebral artery in human brain" was carried out in department of Anatomy, Patna medical College and Hospital , Patna, Bihar. Study duration of two years.

Scalpel, toothed forceps, plane forceps, saw, blunt chisel, pencil, string, digital camera, slide calliper.

The posterior cerebral artery was observed for variation in its course and branching pattern in the 20 posterior cerebral artery of the 10 brains (20 cerebral hemisphere) obtained from cadavers used in routine educational dissection for undergraduate students in department of Anatomy for a period of 1 & 1/2 years from 2016-2018. The dissection was done carefully to clean the artery and then digital photography was taken.

Head was supported on a block and a saggital cut was given through the epicranial aponeurosis from the root of the nose to the external occipital protuberance. Skin, superficial fascia and epicranial aponeurosis was pulled laterally and detached from the temporal lines. Periosteum was stripped from the external surface of the vault of the skull up to the level below the attachment of the temporalis muscles. Now to remove the skull cap or calveria, a pencil mark was made on the skull by encircling it with a string passing no more than 1 cm above the orbital margins and the external occipital protuberance and drawing around it.

A saw cut was made along its line carefully to avoid cutting deeper than marrow cavity. A blunt chisel was introduced into the saw cut and inner table was divided.

P-I segment (from the termination of the basilar artery to the junction with the posterior communicating artery), **P-2 segment** (from the junction of posterior communicating artery & terminates lateral to the posterior edge of the midbrain where the origin of the inferior temporal arteries take place), **P-3 segment** (proceeds posteriorly from the posterior edge of the lateral surface of the midbrain and ends at the anterior limit of the calcarine fissure, and **P4 segment** (includes the branches distributed to the cortical surface). Digital photographs were taken for the record. All the 10 brains selected for the purpose were studied in detail in a similar manner.

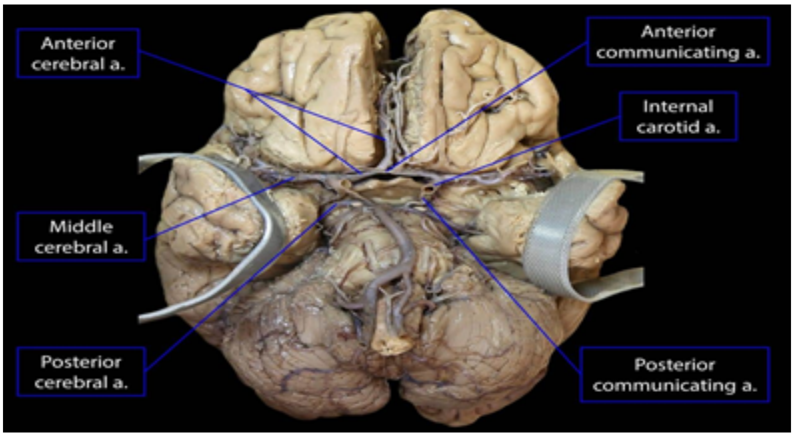
Results

In all the cadaveric brains posterior cerebral artery originates as the terminal bifurcation of basilar artery opposite the upper border of pons in the interpeduncular fossa. In one brain there was unilateral foetal origin of posterior cerebral artery on the left side (photo no.2 and 4). In this case the thickness of left side of posterior cerebral artery was visibly less than the thickness of posterior communicating artery on the same side. This anomaly led to the major part of blood supply to the left side of occipital lobe from internal carotid artery through posterior communicating artery instead of basilar artery.

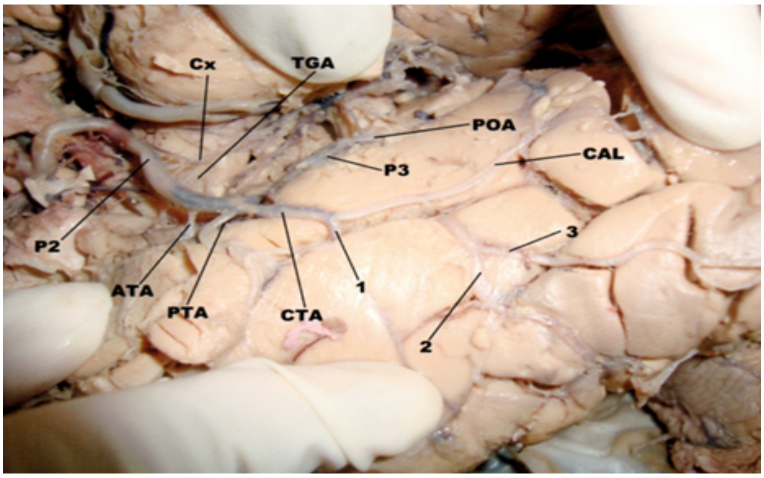
The artery then curves laterally over the crus cerebrii of the mid brain parallel to superior cerebellar artery but separated from it by the third cranial nerve. It joins the posterior communicating artery at the lateral margin of the interpeduncular cistern. The artery divided into four parts along its course as described earlier. Branches of posterior cerebral artery supply the inferior surface of the temporal and occipital lobes. The central branches supply the thalamus, midbrain, choroid plexus, and wall of third and lateral ventricles. **P1 segment;**P1 segment is the precommunicating segment, extends from origin of posterior cerebral artery to posterior communicating artery. Mean length of P1 segment was 7.75mm (ranging from 5mm to 11mm). Mean length of P1 on right side was 7.6mm (ranging from 6mm to 11 mm). Mean length of P1 on the left side was 7.9mm (ranging from 5mm to 10mm). Branches of P1 segment are the posterior thalamoperforating arteries and the long and short circumferential arteries. **P2 segment**

The P2 segment is also called peri mesencephalic or post communicating segment. It starts at the anastomosis of the Posterior communicating artery with the Posterior cerebral artery and ends at the posterior edge of the lateral surface of the midbrain. **P3 segment:** P3 proceeds posteriorly from the posterior edge of the lateral surface of the midbrain and ends at the anterior limit of the calcarine fissure; both P3 segments converge medially. In most of the studied specimens the PCA divided into its major terminal branches, the calcarine and parieto-occipital arteries, before reaching the parieto-occipital sulcus. **P4 segment:** The P4 segment corresponds to the parts of the PCA that course along or inside both the parieto-occipital sulcus and the distal part of the calcarine fissure, which are, respectively, the parieto-occipital and calcarine arteries. and includes the branches distributed to the cortical surface.

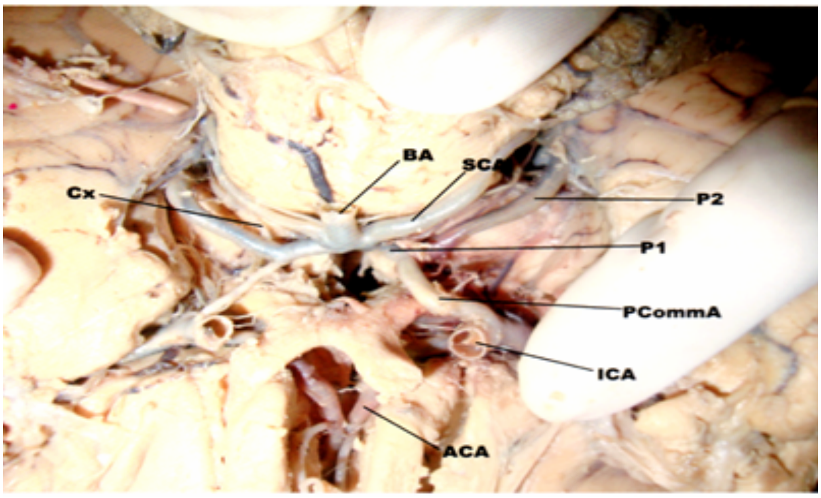
Brain showing the Circle Of Willis in the interpeduncular fossa.



Brain showing the fetal origin of P1 segment on the left side with hypoplastic P1 and thickened Posterior communicating artery (PCommA)

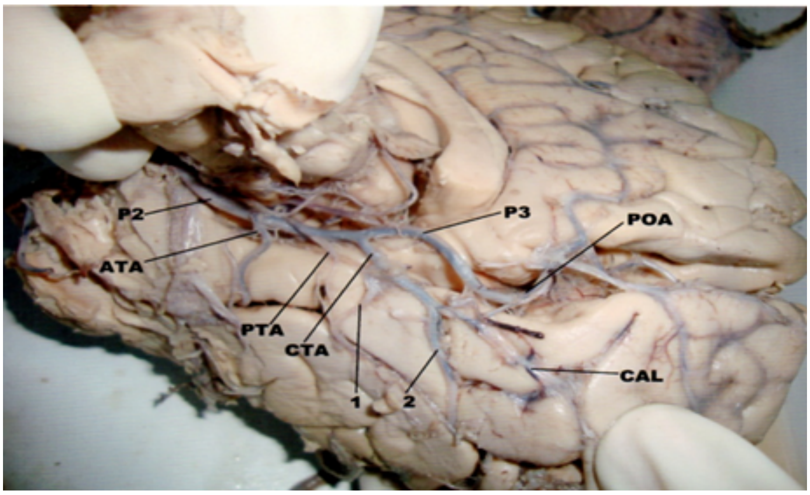


BA- Basilar artery
P1 and P2 segments of posterior cerebral artery
SCA- Superior cerebellar artery
PCommA- Posterior communicating artery
Cx- Circumferential Artery
ICA- Internal carotid artery
ACA- Anterior cerebral artery



Brain showing the origin of the circumferential artery (Cx) and the thalamogeniculate arteries (TGA) from the P2 segment of the posterior cerebral artery

The P2 segment also gives origin to the anterior temporal artery (ATA), posterior temporal artery (PTA) and the common temporal artery (CTA).
Common temporal artery further gives origin to the anterior inferior temporal artery (1), middle inferior temporal artery (2), posterior inferior temporal artery (3) and the calcarine artery (CAL)
The P3 segment continues as the parieto-occipital artery (POA) in the parieto-occipital sulcus.



Brain showing the origin of anterior temporal artery (ATA), calcarine artery (CAL), and the posterior temporal artery (PTA) from the P2 segment of the posterior cerebral artery P3 segment continues as the posterior occipital artery (POA) in the parieto-occipital sulcus.

Discussion

Various method of cadaveric IV injection has been tried with different fixing techniques. Pai and Verma (2007) painted the arteries with water colour after dissection and they took digital photographs through the operating microscope. Richard Gonzalo Párraga et al [5] (2011) injected arteries with red silicone and dissected with microsurgical techniques. Ace Dodevski (2014) did the anatomical analysis of computed tomography angiography (CTA) images. Slobodan V. Marinkovic [6] (1987) perfused specimen with saline solution, then injected with 10% India ink and gelatine or with a radiopaque substance (Micropaque). However in our study meticulous dissection was used to overcome the deficiency. In present study only one out of twenty posterior cerebral arteries showed the unilateral fetal origin of posterior cerebral artery (5% of cases). This case of fetal origin was found on left side. De Silva K and Silva T et al [7] (2009) did a study to reveal 4.4% of foetal and 2.2% of transitional configurations. In Mc Cormick’s study in 1969 suggested that fetal configuration was present in 6% of cases. Padmavathi G and Rajeshwari T et al in 2011 reported in their study that fetal type of PCA was noted in 6.5% of the cases. 11% of the cases in their study exhibited a common trunk of origin of both PCA & SCA. Fetal type of PCA was more on the left side and the overall percentage variations of PCA noted was 17.6%. [8]

Percentage of cases with fetal origin of Posterior Cerebral Artery

Study	Percentage of cases with fetalorigin of PCA
Present study	5%
De Silva K and Silva T	4.4%
Mc Cormick	6%
Padmavathi .G and Rajeshwari .T	6.5%

In present study mean length of P1 segment was 7.75 mm (ranging from 5mm to 11mm). Mean length of P1 on right side was 7.6mm and mean length of P1 on the left side was 7.9mm. Mean length of P1 obtained by Richard Gonzalo Parraga (2011) was 7.7mm (range 4 to 20mm) which is very close to the result obtained in present study. Kaya A H[8] and Dagcinar A in 2010 observed that length of Pl ranges from 2.8mm to 12.2mm with a mean of 6.8. Crauso and Vincentelli (1991) reported average length of P1 segment to be 6.7mm ranging from 2.5 to 14mm.

Length of P1 segment of posterior cerebral artery in mm

Study	**Mean length of P1 segment**	**Range of P1 segment length**
Present study	7.75 mm	5 mm to 11 mm
Richard Gonzalo Parraga	7.7 mm	4 mm to 20 mm
Kaya AH and Dagcinar A	6.8mm	2.8mm to 12.2mm
Crauso and Vincentelli	6.7 mm	2.5 mm to 14 mm

Average number of thalamoperforators from P1 segment

Study	**Average number of thalamo perforators in P1 segment**	**Range in number of thalamo perforators**
Present study	2.35	1 to 4
Marinkovic	2	0 to 10
Richard Gonzalo Parraga	3	1 to 10

In present study about one to two circumferential arteries were seen to arise from the P1 segment on either side. Pai B S, Verma R G et al in 2007 found one to two circumferential branches from P1 segment on both the sides.

P2 SEGMENT:

In present study about three to five thalamogeniculate arteries were seen rising from the P2 segment. The circumferential branches were also seen arising from the P2 segment also. According to the literature available the numbers of thalamogeniculate arteries can vary greatly. Zeal and Rhoton (1978) have reported one to seven (mean 2.4) in number. reported most of the thalamogeniculate arteries to arise from the P2 segment. Pai B. S. Verma R G et al [9] (2007) reported the number of thalamogeniculate arteries from two to twelve with a mean of 7.75. They found equal number of arteries arising from P2 segment as well as P3 segment of posterior cerebral artery. They found one to two circumflex branches arising from P2 segment also. In present study most of the calcarine arteries were the branch of the P3 segment of the posterior cerebral artery (80% cases). In 2 cases (10%) it originated from the common temporal artery. In one case (5%) it arose from the posterior temporal artery and in one case (5%) it arose from the P2 segment of the posterior cerebral artery. Slobodan V. Marinkovic [10](1987) reported in their study that the calcarine artery had the same origin as the parieto-occipital artery, they both arose from the same site of the distal segment of the PCA or from the same terminal stem (called the medial occipital artery) of the PCA. The calcarine artery was singular in 80% of the cases and double in 20%.The single calcarine artery, which arose in the ambient or quadrigeminal cistern or in the proximal part of the calcarine sulcus, entered the latter and ran along it. Milisavljevic M and Marinkovic S [11] (1988) suggested that, the distal segment of the posterior cerebral artery divided into two terminal trunks: the parietooccipital and calcarine artery [12]. These terminal branches arose from P3 portion of the distal segment (84.3%). Richard Gonzalo Parraga [13,14](2011) stated that In present study the P3 segment divided into terminal branches parieto-occipital artery and calcarine artery. These terminal arteries correspond to the P4 segment. According to Zeal and Rhoton (1978) P4 includes branches distributed to the cortical surface [15].

Conclusion

In all the 10 brains the posterior cerebral artery (PCA) was present on either side, arising from the basilar bifurcation. In one brain fetal configuration of PCA origin was seen on left side in which the posterior communicating artery was visible to be much thicker than the P1 segment of PCA. The mean length of P1 segment was 7.75mm, ranging from 11mm to 5mm.

Average number of posterior thalamoperforators arising from the P1 segment was 2.35, ranging from 1 to 4. The circumferential arteries were seen to arise from P1 as well as P2 segments.

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