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Original Research Article

VARIATIONS IN POSTERIOR INFERIOR CEREBELLAR ARTERY AND ITS CLINICAL SIGNIFICANCE IN UTTAR PRADESH REGION: A 64-SLICE CT ANGIOGRAPHIC STUDY

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ABSTRACT

Background: Posterior Inferior cerebellar artery (PICA) is the largest and most distal branch of Vertebral artery (VA) arising near the lower end of olive. Variations of PICA are numerous but have been infrequently reported in this region. Occlusion or blockage of PICA may cause an infarction of the medulla oblongata which plays an important role in circulatory and respiratory functioning. This may lead to lateral medullary syndrome, also called Wallenberg syndrome. The study focuses on normal and variant anatomy of PICA in Uttar Pradesh region of North India.

Materials and Methods: The study population included 100 subjects, of either sex, who underwent Head and Neck CT Angiography in the Department of Radiodiagnosis, King George's Medical College, Lucknow, Uttar Pradesh. The diameters of PICAs of both sides were measured and variations encountered were noted.

Results: Mean diameter of PICA was 1.76±0.64 mm on right side and 1.73±0.60 mm on left side. Mean diameter in males was 1.75±0.62 mm and in females was 1.73±0.62 mm. Variations observed included: Unilateral aplasia of PICA in 16% with equal prevalence on both sides; bilateral aplasia in 3% cases; hypoplasia of RPICA in10% and hypoplasia of LPICA in 6%. VA-PICA variation where the VA continued as posterior inferior cerebellar artery was observed in 8 subjects (4 right, 4 left).

Conclusion: The knowledge of normal diameters and variations in PICA supplying the brain can be a useful guide to the surgeons and interventional radiologists for careful pre-operative planning thus helping them in avoiding potentially life threatening complications.

KEY WORDS: Posterior Inferior cerebellar artery, Wallenburg syndrome, Vertebral artery CT Angiography, VA- PICA, Hypoplasia, Aplasia.

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INTRODUCTION

Arterial supply of brain consists of Anterior and Posterior circulations. Anterior circulation comprises of internal carotid artery and its branches and the Posterior circulation comprises of vertebral artery and basilar artery with their branches.Posterior circulation is also known as Vertebrobasilar system (VBS) and it contributes about 20% of arterial blood supply to the brain.Vertebrobasilar system supplies blood to the posterior part of occipital lobes, posterior portions of temporal lobes, cerebellum, and brainstem [1]. According to textbooks descriptions, vertebral artery (VA), originates from postero-superior aspect of first part of subclavian artery. It traverses through foramen transversaria of all the cervical vertebrae except seventh, passes through the lateral mass of atlas vertebra, enters the cranium and joins the vertebral artery of opposite side at the pontomedullary junction to form the basilar artery (BA) [2]. Branches of vertebral artery include muscular, meningeal, spinal, radicular, proatlantal intersegmental artery and the posterior inferior cerebellar artery (PICA). PICA is the largest and the most distal branch of VA and it arises near the lower end of olive. After its origin it runs laterally along the roots of hypoglossal nerve, forms a caudal loop over dorsolateral aspect of medulla, and turns upwards to pass between tonsil and vermis where it divides into medial (vermian) and lateral (hemispheric) branch where the hemispheric branch supplies the posterior part of the inferior surface of the cerebellum. **(Fig: 1)**

Development:

At the fourth week of embryonic development (4-mm length) several branches of BA and VA (rhombomeric and segmental occipital arteries) [3], passing above, below, and between the rootlets of XII cranial nerve are connected with the primitive lateral vertebrobasilar anastomosis (VBAn). In an early stage (12–14 mm embryo; 35±1 days of estimated ovulation age) only the superior cerebellar arteries (SCAs) supplying the cerebellar rudiment are visible. The potential stem of AICA is recognizable in embryos of 16–18 mm (40±1 days of estimated ovulation age). In the 20-24-mm embryos (44±1 days of estimated ovulation age) the stem of PICA may still be difficult to identify among the numerous arteries supplying the posterior part of the hindbrain. The period between appearance of the cerebellar rudiment and the development of usual origin of PICA from VA extends from 30±1 days (6–7 mmlength embryo) nearly to the end of second month. During this time, following the development of pontine flexure, the rhomboid lips approach and the cerebellum comes into contact with the dorsal aspect of myelencephalon. The inferior cerebellar surface becomes vascularized through a process of angiotrophic vasculogenesis, characterized by development of new vessels by sprouting and branching from the endothelium of preexisting dorsal myelencephalic plexus. Therefore SCA is the original artery for cerebellum whereas the PICA in reality represents an acquired source of vascularization [3,4]. The definitive course of PICA is not established until a later stage when the myelencephalic plexus has added the cerebellum to its fields of vascularization, and the choroid plexus becomes a secondary target that is supplied only via small branches in the adult.

Late appearance of PICA during the ontogenetic process reflects its late appearance in the phylogenesis. In fact, the comparative anatomy of vascularization of posterior cranial fossa in mammals shows the presence of only two vessels destined to the cerebellum, namely the rostral and caudal cerebellar arteries, both originating from the BA [5]. The presenceof a third cerebellar artery in humans originating from the VA, i.e., the PICA, represents a recent phylogenetic acquisition related to the particular development of the neocerebellum.

Variations of PICA are numerous but less have been reported in this and many regions. Reported variations of PICA are in the form of abnormal origin, aplasia, duplication and fenestration. These variations are believed to be developmental anomalies that occur during embryogenesis. Computed tomographic angiography (CTA) is considered as a standardized procedure with excellent image quality for visualizing the carotid and VBS [6]. Therefore the aim of our study was to provide a nomogram for morphometry of PICA and to determine its normal anatomy and variations by computerized tomographic angiography (CTA) in the population of Uttar Pradesh region.

The knowledge about arterial variations supplying the brain can be a useful guideline to the surgeons and interventional radiologists for careful pre-operative planning thus helping them in avoiding potentially life threatening complications.

MATERIALS AND METHODS

Place of study: The study was conducted in Department of Anatomy, KGMU, Lucknow, UP, in collaboration with Department of Radiodiagnosis, KGMU and Department of Radiodiagnosis, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow.

Patients: Approval for this observational, descriptive, cross-sectional study was obtained from the Ethical review board of University. 100 subjects (male= 52, females= 48), of all age groups, of either sex were studied for a period of 1 year (September 2016 - August 2017). Inclusion criteria for all age groups included, willingness to participate in the study, patients undergoing Brain Angiography, and CVJ Angiography whereas exclusion criteria included refusal, pregnancy, allergy to iodine, renal insufficiency, history of head trauma, cerebral surgery, vasculitis syndrome, vertebrobasilar dissection or near complete occlusion and space occupying intracranial lesions likely to distort the vascular anatomy.

Pre-procedure precautions: Patients were enquired to rule out presence of any drug allergy to avoid the occurrence of any untoward anaphylactic reaction during the procedure**.** They were asked to remain empty stomach and Blood urea and creatinine levels were evaluated prior to procedure.

CT Angiography Protocol: CT Angiography was performed on a 64-slice multidetector spiral CT scanner (BRILLIANCE CT, Philips medical system, Netherland, B.V.5684 PC Best.The Netherlands). installed in 64-slice CT scan centre of the Department of Radiodiagnosis, King George's Medical University, Lucknow and Sanjay Gandhi Postgraduate Institute of Medical Sciences , Lucknow. CT Angiography of all patients was done after overnight fasting. Patients were trained for breath holding method which was required during the procedure.

Procedure: CT Angiography was performed after receiving a written informed consent from the concerned subject. The patient was positioned supine and head immobilized by adhesive strap. The images were acquired on a multislice (64) spiral CT scanner. The area from C3 vertebra to the vertex was scanned using the following scanning parameters: detector rows-64,detector collimation of 64 × 0.6255mm , pitch -0.9, gantry speed -0.75 sec, slice thickness – 0.625mm, tube load 150 -400 mA , tube voltage -120 kV , FOV 220-240 mm and matrix 512x512. Plain CT followed by CT angiography was performed. 80-100ml of non ionic contrast medium was injected at the rate of 5ml/sec followed by saline flush of 40 ml through the antecubital vein with 18 gauge cannula using power injector. The time of delay was chosen by bolus tracking. Common carotid artery was monitored in real-time with low-dose dynamic scanning at C5 vertebra. The diagnostic scan was manually started once contrast reached the Common Carotid Artery. Source images, thus obtained were transferred to the workstation dedicated to the scanner where the processing was done. The final post-processed images along with the axial slices were used for analysis and reporting.

Fig. 1: Schematic diagram showing normal origin and course of cerebellar arteries.

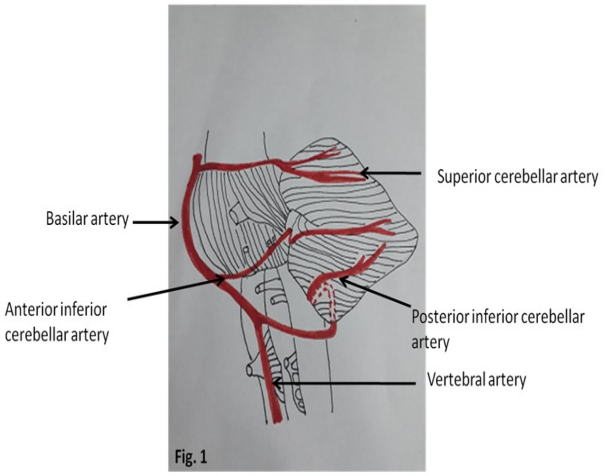


Fig. 2: Brain CT angiography (CTA) - Axial image.

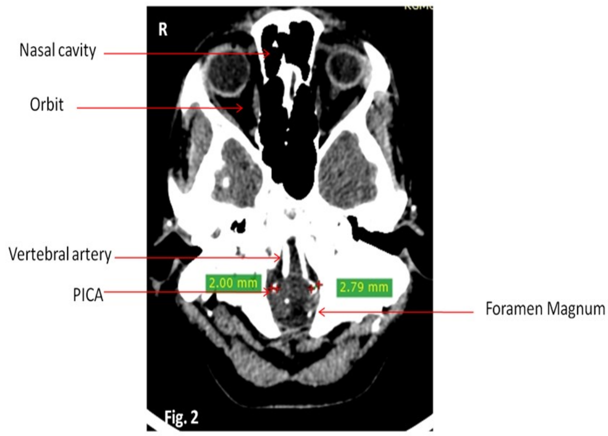


Fig. 3: Three dimensional volume rendered (3D- VR) image of brain CTA displaying normal anatomy of vertebrobasilar system.

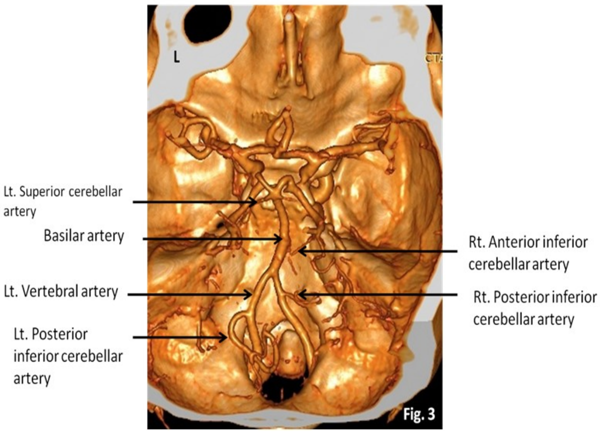


Fig. 4: Axial image of brain CTA showing hypoplastic left PICA.

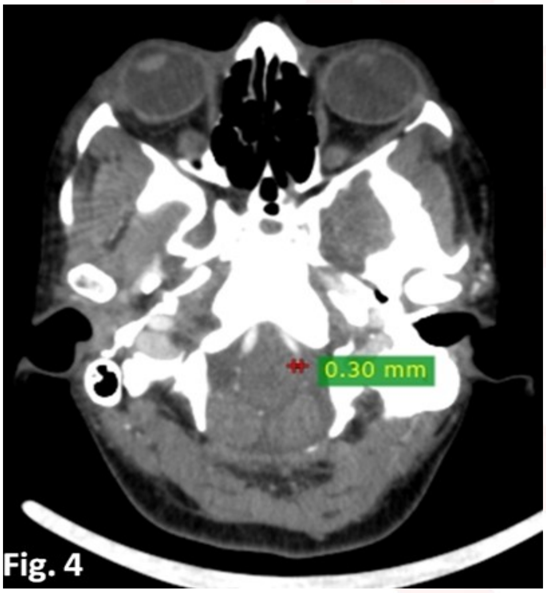


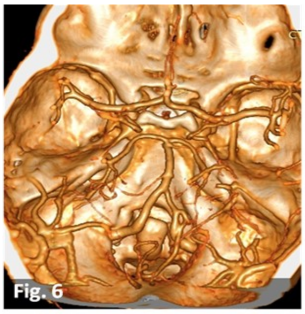
Fig. 5: Axial image of brain CTA showing hypoplastic right PICA.

Fig. 6: 3D volume rendered image of brain CTA showing aplasia of left PICA.

Fig. 7: 3D volume rendered image of brain CTA showing aplasia of right PICA.

Fig. 8: 3D volume rendered image of brain CTA showing left VA-PICA (black arrow).

Fig. 9: 3D volume rendered image of brain CTA showing right VA-PICA (black arrow).



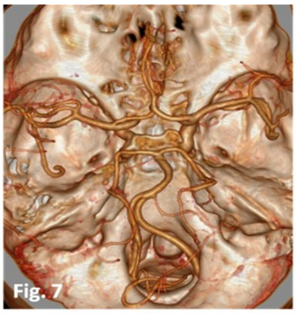


Fig. 10: 3D volume rendered image of brain CTA showing aplasia of left PICA and dominant left AICA (black arrow)

Image Analysis: Images were processed on an extended brilliance workspace version 4.0. CT image interpretation was done by using various techniques like multiplanar reconstructions, maximum intensity projection (MIP) and volume rendered technique (VRT). Axial source images and 3-D reconstructed images were helpful in evaluating complex vascular anatomy (**Figs: 2,**

Fig: 3). Interpretation was done by Radiologists and Anatomists. Image analysis was done for both right and left PICAs for appreciating normal anatomy and presence of variations like;

• Duplication (Two distinct arteries, separate origins and no distal arterial convergence) [7]

• Fenestration (Duplication of a portion of the artery) [8]

• Hypoplasia (PICA: Diameter d”1 mm) [1]

• Aplasia (Non visualization of PICA in CTA)

• VA-PICA (Vertebral artery continuing as PICA) [9].

OBSERVATIONS AND RESULTS

One hundred (100) patients were included in the study (Males=52, Females=48). Age ranged from 21-80 years with mean age = 48.86 ± 16.73 years.

The Analysis of images revealed that 71 PICAs on the right side and 75 PICAs on the left side displayed normal anatomy. The remaining arteries were found to be variant in form of hypoplasia, aplasia and VA-PICA. Among the arteries that displayed normal anatomy the mean diameter of PICA was observed to be 1.76±0.64 mm on the right side and 1.73±0.60 mm on the left side. Mean diameter in males and in females was found to be 1.75±0.62 mm and 1.73±0.62 mm respectively.

Diameters of PICAs when tabulated ranged from 1.1-3.0mm in 75%, Hypoplasia (d”1 mm) of PICA was observed in 12% whereas it ranged from 3.1-4.0mm in only 2%. **(Table-1).**

Table 1: Observed diameters of Posterior inferior cerebellar artery (PICA).

Range (mm)	Right PICA		Left PICA		Total	
	n	%	n	%	n	%
≤1	10	5	14	7	24	12
1.1-2.0	52	26	48	24	100	50
2.1-3.0	24	12	26	13	50	25
3.1-4.0	3	1.5	1	0.5	4	2

Study subjects were categorized according to their age in different groups to observe the PICA diameters across various ages. The mean diameter of PICA was observed to increase with increasing age but the difference in mean diameter among different age groups was statistically insignificant **(Table-2).**

Table 2: Mean diameter of PICA in different age groups.

	Age groups (years)	Mean diameter ±SD (mm)
	<20	1.61±0.22
	20-40	1.69±0.51
	40-60	1.77±0.39
	60-80	2.50±0.14
‘ANOVA’	“p”	0.08

Observed variations of Posterior inferior cerebellar artery included: PICA hypoplasia, PICA aplasia and VA terminating as PICA (VA-PICA). **(Figs: 4, 5, 6, 7, 8, 9).** Association of these variations with laterality and gender was observed and their statistical significance was calculated.

Unilateral PICA hypoplasia was observed in 16% cases whereas bilateral in 4%. Occurrence of right sided PICA hypoplasia was more common (10%) than left (6%). **Bilateral PICA hypoplasia** was observed in 4%. Difference between the two was statistically insignificant. **Unilateral PICA aplasia** was observed in 16% cases with equal prevalence on both sides. **Bilateral PICA aplasia** was noted in 3 % cases. Unilateral PICA aplasia was found to be associated with dominant AICA of ipsilateral side. 7% cases of PICA aplasia on the right side and 7% cases of PICA aplasia on the left side, were associated with dominant AICA **(Fig:10).**

VA-PICA was observed in 8% cases with equal prevalence on both sides **(Table-3).**

Table 3: Observed Variations of Posterior Inferior Cerebellar Artery (PICA).

Variations of PICA	Unilateral					Bilateral	% Prevalence
	Right	Left	Total	x^2	“p”		
Hypoplasia	10	6	16	1	0.317	4	20
Aplasia	8	8	16	0	1	3	19
VA-PICA	4	4	8	0	1	0	8

“chi square test”

DISCUSSION

Posterior inferior cerebellar artery was observed in 100 study subjects that were selected randomly. Anatomy was found normal in RPICA in 71 and LPICA in 75. The mean diameter of PICA was observed to be larger on right side (1.76±0.64mm) than on left side (1.73±0.60mm). Our findings were similar with that of Akgun et al (2013) who also found right PICA to be larger

(1.67 ± 0.45mm) as compared to left side (1.64 ± 0.37mm) [1]. Shrontzet al (1986) in a cadaveric study reported larger left PICA (1.8±0.1mm) than right PICA (1.7±0.1mm) [10]. The diameters measured by these authors were in concurrence with present study however readings noted by Pai et al (2007) were comparatively lesser though they also reported that right PICA was (1.23 mm) marginally wider than left (1.21mm) [11]. We also noted that mean diameter of PICA was larger in males (1.75±0.62mm) as compared to females (1.73±0.62mm) but the difference among gender groups was statistically insignificant. We were unable to compare this data with other studies as literature remains silent regarding this aspect.

In the present study diameters of PICA ranged from 1.1-4.0mm. In majority of arteries (75%) it ranged from 1.1-3.0mm, so we can infer that normal range of diameter of PICA in UP region of North India is 1.1-3.0mm. One study conducted on the Indian population in 25 cadaveric brains, describes the range of diameter for PICA as 0.5-2.0mm; lesser than that observed in present study [11].

The knowledge about range of normal diameter of arteries is important to acknowledge hypolasia and/or dilatation in order to avoid any misinterpretation of the clinical situation.

The mean diameter of PICA was observed to increase with increasing age, but the difference in mean diameters among different age groups was statistically insignificant. The increase in diameter in 60-80 year age group in relation to 40-60 year age group was much more as compared to other age groups. Elastin is a key component for arterial wall integrity and functionality, effects of ageing on elastin explains the basis of wider arteries with increasing age. Enzymatic degradation of elastin leads to loss in compliance of artery [12] and compensatory increase in diameter due to loss of vasomotor tone [13].

Along the course of our study various types of variant arteries were encountered which included PICA aplasia, PICA hypoplasia and VA-PICA.

PICA aplasia was reported in 19 % cases out of which it was unilateral in16% cases with equal prevalence (8%) on both sides and bilateral in 3%. PICA aplasia were found to be mostly associated with dominant AICA of ipsilateral side. 7% cases of PICA aplasia on the right as well as left side were associated with dominant ipsilateral AICA in these cases (Fig:10). Akgun et al (2013) found aplasia of PICA in 24.4% cases on the right side and in 19.3% on the left side. Dominant AICA was seen in 24.4% cases on the right and 19.3% on the left side. They also stated that isolated aplasia of right PICA was the most common variation observed in their study [1]. Pekcevik & Pekcevik (2013) found aplasia of PICA in 12.6% cases on right side and 19.1% on left side and its association with dominant AICA was not reported [14].

PICA diameter d”1mm was our criterion for labeling PICA as hypoplastic [1]. Hypoplasia of PICA was the most common variation observed in 20% cases out of which 16% were unilateral and 4% bilateral. Left sided hypoplasia was commoner (10%) as compared to right (6%). We could not compare our findings as we could not find other studies reporting the exact values of hypoplastic arteries as a percentage of the total. Although vertebral artery hypoplasia in previously published literature is seldom shown as a leading risk factor for stroke in vertebrobasilar (posterior) circulation, its occurrence is not negligible and in coexistence with known risk factors of stroke may increase the negative clinical impact.

Usually in patients with aplasia and hypoplasia of PICA, the ipsilateral anterior inferior cerebellar artery (AICA) supplies blood to the posterioinferior part of the cerebellum. There have only been a handful of reported cases where a single PICA feeds both cerebellar hemispheres, and although the incidence of this anomaly is unknown a report by Cullen et al. (2005) hypothesizes that it occurs in less than 0.1% of individuals [15]. We were unable to observe any similar variation during the course of our study.

VA did not join with its counterpart to form basilar artery in 8% cases, where, it instead continued as PICA. This has been reported in literatures as VA-PICA. Pekcevik &Pekcevik (2013) found VA-PICA in 4.4% patients [14]. VA-PICA was observed by Liu et al (2017) in 6.3%

healthy individuals and 18.7% diseased patients [9], and in these individuals smaller diameter of VA, BA and PCA was noted and was also associated with significant lower mean flow velocity and higher pusatility index in the vertebral artery which explains that VA-PICA may have a detrimental impact on cerebral hemodynamics and can be a risk factor for cerebrovascular diseases. In present study out of 8% cases of VA-PICA, ipsilateral hypoplasia of vertebral artery was also observed in 6% cases. It was also observed that the prevalence of VA-PICA was equal on both sides, whereas Akgun et al (2013), observed higher prevalence on right side [1].

The knowledge about these variations of PICA in the form of absence, hypoplasia and VA-PICA are important for the Radiologists and Neurosurgeons.

CONCLUSION

In conclusion, we have made an attempt to prepare a normogram for morphometry of PICA for the population of Uttar Pradesh region of North India. Such data about normal diameters may be helpful for anatomists, neurosurgeons and radiologists for systematic analysis of PICA in this region while performing CTA. We also report the prevalence of various clinically relevant variations of PICA in the form of aplasia, hypoplasia and VA-PICA observed in our region.

ABBREVIATIONS

AICA- Anterior Inferior cerebellar artery
CTA- Computed tomographic angiography
LPICA- Left Posterior Inferior cerebellar artery
PICA- Posterior Inferior cerebellar artery
RPICA- Right Posterior Inferior cerebellar artery
SCA- Superior cerebellar artery
VA- Vertebral artery
VBA- Vertebrobasilar artery
VBAn- Vertebrobasilar anastomosis

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Conflicts of Interests: None

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