

## A Morphometric Study of Vascular Patterns in Primary Auditory Area of Human Brain

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### ABSTRACT

**Objectives:** To investigate the blood supply of primary auditory area to provide comprehensive knowledge of morphology and variations of cerebral vessels supplying this area and to illuminate the collateral vessels to this area.

**Subject and methods:** A total number of 50 cerebral hemispheres were obtained from cadavers and put in 10% formalin for one week so as to fix them. A mixture of gelatin and Indian ink of various colours was injected in anterior cerebral artery, middle cerebral artery and posterior cerebral artery separately. Measurement of length and diameter of each vessel was made by digital vernier caliper.

**Results:** The middle cerebral artery is the sole supply to the primary auditory area while the posterior cerebral artery appeared as collateral artery to the primary auditory area.

**Conclusion:** Variations of arteries supplying the primary auditory area already mentioned were noted frequently and significantly. Variations in appearance were noted as smooth and nodular. Variations regarding course were noted as straight or tortuous. Modularity and tortuous course could explain the high incidence of cerebrovascular accidents in mankind. The presence of collateral vessels to this area can modify the outcome of cerebral infarcts.

**Key words:** Anterior cerebral artery, middle cerebral artery, posterior cerebral artery.

### INTRODUCTION

The primary auditory area (area 43) is centered in the superior temporal gyrus of temporal lobe<sup>1</sup>. The temporal lobe is bounded above and behind by lower part of an imaginary line drawn from parieto occipital sulcus to pre occipital notch. Above by horizontal part of posterior ramus of lateral sulcus behind and below by the inferolateral border. Its anterior end is temporal pole. There is bilateral projection of auditory fibers to this area, therefore a unilateral lesion will not result loss of hearing. Two or three temporal branches of the middle cerebral artery supply the auditory area.

Through the use of variety of techniques including analysis of behavioural and cognitive change due to brain injury and a variety of staining techniques, function maps of the brain have been built up over many years, providing the neurological basis for functional specialization of the cerebral arteries and other brain structures. In the 1980's positron emission tomography (PET) which measures function related changes in regional cerebral blood flow, closely followed in early 1990's by functional magnetic resonance imaging (MRI) which measures blood oxygen level dependent signals revolutionized

the field. These techniques brought noninvasive high-spatial resolution approaches to brain structure-function studies for the first time enabling measurement of region specific changes of brain activity correlated with particular cognitive, motor or sensory tasks<sup>2</sup>.

The intracranial aneurysms were described for the first time at autopsy in 1705. The first description of spontaneous sub arachnoids haemorrhage due to ruptured aneurysm proved by autopsy was reported. The development of angiography in 1927 facilitated the diagnosis and treatment of cerebral aneurysms<sup>3</sup>.

In a comparative study on variety of animals, the hemispheres were divided into well defined lobes. The anterior frontal lobes were honored as the seat of man's highest intellectual faculties and sensation. Language was considered as faculty to establish a constant relation between ideas and signs and the ability to articulate was placed in the posterior part of the 3<sup>rd</sup> frontal convolution of the left hemisphere. The identification of the seat of motor speech was followed slightly more than a decade later by the cerebral injury responsible for sensory aphasia. This discovery interrelated the written aspects of communication in the occipital cortex with auditory aspects in Wernicke's area in the temporal lobe and motor expression in Broca's area in the frontal lobe adjacent to the laryngeal area of the motor cortex<sup>4</sup>.

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It was concluded that the accessory middle cerebral artery supplied the cortical areas in the territory of the orbitofrontal and prefrontal arteries. The anterior temporal lobe and the anterior frontal lobe are supplied by duplicated MCA and accessory MCA respectively. The development of the duplicated MCA and accessory MCA is an anomalously early ramification of the early branches of the MCA<sup>5</sup>.

## MATERIAL AND METHODS

It was cross sectional analytical study conducted at the Gujranwala Medical College Gujranwala. Fifty embalmed and non-embalmed human brains were collected from recently deceased adult males between twenty to sixty years of age from various teaching institutes, forensic department KEMU Lahore and Anatomy Departments of SIMS, KEMU, FJMC, and AIMC with permission.

Skull cap was cut by electric saw passing through middle of frontal bone, squama of the temporal bone and the occipital bone. Skull cap was removed. After incising the falx cerebri and tentorium cerebelli hand was passed over the surface of brain and it was removed through epidural space without any injury to the blood vessels compression on the brain.

Each brain was examined for any bleeding, softening or any other pathological lesion like infarcts and specimens with these lesions were excluded. Then each selected brain was put in 10% formalin jar for one week so that it got fixed.

After one week dura was removed gently by forceps and intravenous branula no.24 was passed into each anterior, middle and posterior cerebral arteries separately at different times. An injection medium consisting of mixture of gelatin with undiluted blue Indian ink was injected by syringe into anterior cerebral artery after ligating anterior communicating artery. After injection the branula was removed and ligature applied to the artery so that the dye may not escape. Now the branula was passed in the middle cerebral artery and an injection medium consisting of mixture of gelatin with undiluted red Indian ink was injected and ligature applied to the artery. The contrasting colours clearly demarcated the blood vessels supplying the functional areas of the brain. As the vessels of the brain were tortuous it was difficult to measure their length by digital caliper, so a flexible copper wire was molded along the course of each vessel. The wire was cut according to the length of the vessel and straightened out and actual length of the vessel was computed on the digital caliper.

The diameter of the blood vessel was computed by digital electronic vernier caliper. The external diameter of each vessel was measured at proximal, middle and distal compartments. The mean diameter was noted for statistical analysis.

## RESULTS

**Gross Distribution of Vessels:** The posterior temporal artery branch of the inferior trunk of the MCA was the main artery to the primary auditory area. It was present in 43 cases (86%). The occipitotemporal artery branch of the posterior cerebral artery appeared as the collateral (additional) artery to the primary auditory area in 7 cases (14%).

**The Posterior Temporal Artery (Table 1):** Out of 50 cases the posterior temporal artery was present in 43 cases (86%). It originated from inferior trunk of MCA in all cases. It was seen to originate near the lateral sulcus and passed downwards with a straight course in 36 cases (88%). While it followed a tortuous course in 7 cases (22%). Its surface appeared nodular in 12 cases (28%). In another 31 cases (72%) it appeared smooth. It terminated in superior temporal gyrus by giving 1 to 2 cortical branches. Its mean diameter was found to be 1.16 mm±0.03mm. Its mean length was noted to be 19.6mm±0.22mm.

**The Occipitotemporal Artery (Table 2):** Out of 50 cases the occipitotemporal artery appeared as collateral artery (additional artery) to the primary auditory area in 7 cases (14%). The occipitotemporal artery was seen to arise from posterior cerebral artery in all cases. It originated near the occipitoparietal sulcus and passes over the middle and superior temporal gyri to supply the primary auditory area. It followed a horizontal backwards course in 6 cases (88%). In other 1 case (12%) it showed an upward curve to reach the auditory area. It appeared smooth in 5 cases (72%). In 2 cases (28%) it was nodular. Its maximum and minimum diameters at proximal segment were 1.22mm and 1.14mm respectively. Its average diameter at central segment was 1.15mm. Its maximum and minimum diameters at distal segment were 1.11mm and 1.05mm respectively. Its average diameter at distal segment was 1.08mm. Its mean diameter was found to be 1.13mm±0.03mm. It terminated at the inferior frontal gyrus into 1 to 3 branches. During its course it passed over the superior temporal gyrus. Its mean length 16.32mm±0.26mm and the mean diameter of its terminal branches was 1.02mm±0.02mm.

**ORIGINAL ARTICLE**

Table 1: Morphometric variable of the Posterior Temporal Artery: (n=43)

Origin	Surface		Course		Mean	Mean
ACA	Nodular	Smooth	Straight	Curved	Diameter (mm)	Length(mm)
	12 cases (28%)	31 cases (72%)	36 cases (88 %)	7cases (22%)	1.16±0.03	19.6±0.22

Table 2: Morphometric variable of the Occipitotemporal Artery (n=7)

Origin	Surface		Course		Mean	Mean
ACA	Nodular	Smooth	Straight	Curved	Diameter(mm)	Length(mm)
	2 cases (28%)	5 cases (72%)	6 cases (88%)	1 case (12%)	1.13±0.03	16.32±0.26

**DISCUSSION**

Variations of appearance of cerebral vessels supplying the functional areas of brain are described to represent some diseases of intracranial vasculature. Fibromuscular dysplasia involving the intracranial vessels revealed the beaded appearance of the vessels<sup>5</sup>. Our study has shown significant difference of smooth and beaded appearance in primary auditory area. The beaded appearance may be indicative of various pathological conditions of vessels.

In our study the most common pattern of initial branching of MCA was by bifurcation (90%) while in another study<sup>7</sup> this pattern was noted in (64%) in 70 cerebral hemispheres. It was claimed that the pattern of origin of the cortical vessels from the main trunk and from the secondary trunk can help to perform microvascular reconstructive procedure such as anastomosis, grafting, and reimplantation of branches in insular area of the middle cerebral artery.

In another study<sup>8</sup> on variability of the divisions of the cortical branches of the posterior cerebral artery it was found that the number of the proper cortical arteries is considered to show 16 variations. In seven hemispheres (7.4%) intermediate trunks were not observed. In (92.6%) there was present primary intermediate trunk. Both posterior cortical arteries and cortical arterial groups reached the first five cortical areas of the posterior cerebral artery. The last cortical area was reached by cortical arterial group only. In our study five groups of cortical arteries were seen and all reached the cortical areas of the posterior cerebral artery. The Occipitotemporal artery branch of the posterior cerebral artery appeared as additional artery to primary auditory area in our study.

In another study<sup>9</sup> on the variations of anterior and middle cerebral arteries it was found in 65% cases, the path is arch shaped but in 44% it is straight and oblique in direction. While in 1% it has wavy path. The results are comparable to our study.

Myogenic properties of cerebral blood vessels supplying the primary auditory area of brain were analysed from normotensive and hypertensive rats. In case of posterior cerebral arteries hypertensive rat vessels were significantly narrowed and both wall

thickness and wall radius ratios were increased<sup>10</sup>. The tortuous worm like vessels was found in the primary auditory area of our study. These could be linked to such hypertensive phenomenon. MCA strokes involve the territory of face and upper limb with loss of hearing. Their incidence increases with age. This shows involvement of the primary motor area and primary auditory area. It causes contralateral hemiplegia<sup>11</sup>. In our study also MCA branches are found to nourish these areas.

The PCAs are paired vessels, usually arising from the top of the basilar artery and curving laterally, posteriorly, and superiorly around the midbrain. The PCA supplies parts of the midbrain, subthalamic nucleus, basal nucleus, thalamus, inferior temporal lobe, and occipital and occipitoparietal cortices. In addition, the PCAs, via the posterior communicating arteries (PCOM), may become important sources of collateral circulation for the middle cerebral artery (MCA) territory<sup>12</sup>. In our study the posterior cerebral artery appeared as collateral vessels to primary artery area.

The middle cerebral arteries supply blood to the cortical areas involved in speech, language and hearing. The left middle cerebral artery provides Broca's area, Wernicke's area, Heschl's gyrus, and the angular gyrus with blood. Also, the "head" and "neck" areas of the motor and sensory strips in both hemispheres receive their blood supply from the middle cerebral arteries. Damage to these cortical areas on either side of the brain can impair motor speech and hearing functions<sup>13</sup>. In our study the MCA supplies the same cortical areas.

It is reported that an anatomic and morphologic variations of the vertebral artery are of immense importance in surgery, angiography and all non invasive procedures. The abnormal origin of vertebral artery may favour cerebral disorders because of alterations in cerebral hemodynamics. In our study occipitotemporal artery showed variable course and appearance and could be responsible for variable outcome of cerebral infarcts in primary auditory area<sup>14</sup>.

The primary area of auditory cortex is characterized by neurons which respond with shorter latency and generally higher of activity than those in surrounding secondary or association areas. The

metabolic need of these neurons is provided by the local blood supply. Blood supply to auditory cortex is via a branch of the MCA<sup>15</sup>. In our study posterior temporal branch of MCA supplied this area.

## CONCLUSION

This study gives a comprehensive knowledge of blood supply of primary auditory area of brain. MCA is the major blood supply to the primary auditory area while the PCA appeared as the collateral vessels to this area. Variations of arteries supplying the primary auditory area already mentioned were noted frequently and significantly. Variations in appearance were noted as smooth and nodular. Variations regarding course were noted as straight or tortuous. Nodularity and tortuous course could explain the high incidence of cerebrovascular accidents in mankind. The presence of collateral vessels to each functional area can modify the outcome of cerebral infarcts.

The present study will have obvious implication for determining the technical feasibility for diagnostic and surgical procedure related to cerebral vasculature.

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