ORIGINAL ARTICLE

Double Blood Supply of Broca's Area of Human Brain

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ABSTRACT

Objective: To elucidate the double supply of blood to the primary motor speech area (Broca's area) and provide the Morphometric data of collateral circulation to this area.

Subject and methods: A total number of 100 cerebral hemispheres were obtained from cadavers and put in 10 percent formalin for one week so as to fix them. A mixture of gelatin and Indian ink of various colours was injected in ACA, MCA and PCA separately. Measurement of length and diameter of each vessels was made by digital vernier caliper.

Results: The middle cerebral artery was the major artery supplying this area while the collosomarginal artery appear as collateral artery in significant cases and this double supply to this area could be the cause of better outcome of cerebral infarcts of this area.

Conclusion: It could explain the better survival rates in cerebral ischemia of this area.

Key words: ACA=Anterior cerebral artery, MCA=Middle cerebral artery, PCA=Posterior cerebral Artery

INTRODUCTION

The collateral vessels may modify the effects of cerebral ischemia. There is usually not enough redundancy in the blood vessels of the brain to support function if one vessel is suddenly occluded. Many smaller penetrating brain vessels as the lenticulostriate branches of MCA that supply the basal ganglia and internal capsule, as well as the penetrating branches from vessels on the brain surface that supply deep white matter, are terminal arteries. This means that they form few if any connections with other arteries. When they are occluded, the brain regions they supply will therefore become ischemic. Other vessels form anastomoses that potentially could protect the brain from infarction, or limit the amount of damage, by providing alternative routes for blood flow[1].

Motor speech area (Broca's area 44 & 45) is situated in pars traingularies and opercularis of the inferior frontal gyrus in the dominant hemisphere (left hemisphere in right handed and right hemisphere in left handed persons). It is a centre for initiation of speech as it plays the essential role in movements of tongue, lips and larynx. A lesion of this area results in "motor aphasia"[2].

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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 3rd 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 Wernick's area in the temporal lobe and motor expression in Broca's area in the temporal lobe adjacent to the laryngeal area of the motor cortex[3].

Attempts to understand the varied structure-function relationships within the human brain have a long history. Through the use of variety of techniques including analysis of behavioral 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[4].

The variations in the frontal lobe artery resulted in tonic and colonic seizures due to a focus in the left frontal region where blood was supplied by the contra lateral fronto-orbital artery. The region was vulnerable to ischemic changes due to decreases in blood supply[5].

The middle cerebral artery was found to supply the cortical areas in the territory of the orbitofrontal and prefrontal arteries. The anterior temporal lobe and the anterior frontal lobe are supplied by the 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[6].

Two cases of acute embolic occlusion of the internal carotid artery and the middle cerebral artery in association with a patent accessory MCA described that the frontal lobe was salvaged to some extent did not provide sufficient collateral blood supply to the MCA territory to spare rest of the frontal lobe[7].

Language has been linked to the Broca's area since Paul Peirie Broca's reported impairments in two patients. They had lost the ability to speak after injury to the posterior inferior frontal gyrus. Since then, the approximate region he identified has become known as Broca's area, and the deficit in language production as Broca's aphasia[8].

MATERIAL AND METHODS

It was cross sectional analytical study conducted at the Post Graduate Medical Institute Lahore. Hundred 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 cerebreri and tentorium cerebrelli 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 artery 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 legating anterior communicating artery. After injection the branula was remove 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.

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After one week dura was removed gently by forceps and intravenous branula no.24 was passed into each anterior, middle and posterior cerebral artery 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, middle cerebral artery and posterior cerebral artery separately.

As the vessels of the brain were torturous 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 frontal artery branch of superior trunk of MCA was found to be the major source of blood supply to the Broca's area as it was present in all hundred cases while the callosomarginal artery branch of pericallosal artery a branch of ACA appeared as dual blood supply to Broca's area in 4 cases (4%).

The Frontal Branch of MCA (Table 1): First we studied the frontal branch of MCA. Out of 100 cases it originated from the superior trunk of MCA in all cases (100%). It showed a nodular surface in 41 cases (41%). In another 59 cases (59%) it appeared smooth. It originated near lateral sulcus of cerebral hemisphere and passed over the inferior frontal gyrus with straight course in 68 cases (68%). It followed a torturous forward course in 32 cases (32%). It terminated into 1 to 2 cortical branches. Its maximum and minimum diameters at proximal segment were 1.36mm and 1.24mm respectively. Its average diameter at proximal segment was 1.30mm. its maximum and minimum diameters at central segment were 1.26mm and 1.16mm respectively. Its average diameter at central segment was 1.21mm. Their maximum and minimum diameters at distal segment were 1.12mm and 1.04mm respectively. Its average diameter at distal segment was 1.08mm. its mean diameter was found to be 1.19±0.02mm.ts mean length was noted to be 9.6mm±0.22mm. the mean diameter of its cortical branches was 1.02mm±0.03mm.

The Callosomarginal Artery (Table 2): The callosmarginal artery out of 100 cases was found to supply the Broca's area in 4 cases (4%) as collateral (additional) vessel. It was found to originate from pericallosal artery in 3 cases (75%). In another 1 case (25%) which originate from ACA. It surface was found to be smooth in 2 cases (50%). While in other 2 cases (50%) it appeared beaded. It followed torturous course in 1 case (25%). In other 3 cases (75%) it followed straight course. Its maximum and minimum diameters at proximal segment were 1.53mm and 1.42mm respectively. Its average diameter at proximal segment was 1.47mm. Its maximum and minimum diameters at central segment were 1.35mm and 1.24mm respectively. It average diameter at central segment was 1.29mm. Its maximum and minimum diameters at distal segment were 1.26mm and 1.15mm respectively. Its average diameter at distal segment was 1.20mm. Its mean diameter was found to be 1.32±02mm. its mean length was noted to be 17.6mm±0.22mm. It terminated in to 1 to 2 cortical branches. The means diameter of its cortical branches was 1.04mm±0.05mm.

Table 1: Morphometric variables of the Frontal Branch of MCA artery:

Origin (n=100)	Surface		Course		Mean	Mean
ACA	Nodular	Smooth	Straight	Curved	Diameter(mm)	Length(mm)
100	41 cases (41%)	59 (59%)	68 (68%)	32 (32%)	1.19±0.02	9.6±0.22

Table 2: Morphometric variables of the callosomarginal artery

Origin		Surface		Course		Mean Diameter	Mean Length
From pericallosal artery	From ACA	Nodular	Smooth	Straight	Curved	Diameter(mm)	Length(mm)
3 cases (75%)	1 (25%)	2 (50%)	2 (50%)	3 (75%)	1 (25%)	1.32±02	17.6±0.22

DISCUSSION

Duplication of middle cerebral artery and one accessory middle cerebral artery were studied in two patients and it was noted that the double vascularization of the hemisphere can give rise to strokes with a better progression and prognosis despite the occlusion of one of the middle cerebral artery[9]. In our study 4 cases (4%) of collateral blood supply to the Broca's area was provided by callosomarginal artery. It was described that an accessory middle cerebral artery arises from the anterior cerebral artery and go to a territory usually supplied by the middle cerebral artery. This occurred in 3% of 347 cases[10]. In our study the incidence of callosomarginal artery was 4% of 100 cases.

In an another study[11] 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% the pre communicant segment of anterior cerebral artery it has wavy path. The results are comparable to our study.

In another study[12] one accessory MCA and the early branches were given off before the perforators in two middle cerebral arteries, making an incidence of anomalies of 3%. There was no aneurysm. The results are comparable to our study.

Two right-handed patients with clinical evidence of major infarction in the territory of the left anterior cerebral artery developed a profound but transient aphasia characterized by (1) a striking dissociation between intact repetition and grossly disturbed spontaneous conversational speech, (2) an absence of phonemic paraphasia, (3) a lack of speech inhibition and (4) relative preservation of conformation naming and comprehension. Despite the initially profound motor aphasia, serviceable spontaneous conversational speech returned in two to three months. In fact there may have been damage to the pre-motor area (particularly the supplementary motor region), an area that has been shown to play a role in the initiation, continuation and inhibition of speech[13]. These results show involvement of anterior cerebral artery in supplying the motor speech area. In our study the callosomarginal artery branch of ACA appeared as collateral supply to the motor speech area.

MCA strokes involve the territory of face and upper limb with aphasia. Their incidence increases with age. This shows involvement of the primary motor area and Broca's area. It causes contra lateral hemiplegia[14]. In our study also MCA branches are found to nourish these areas.

Clinical, radiological and pathological studies in patients with stroke, presenting with pathological laughter as heralding manifestation, have shown lesions in the internal capsule and thalamus, basal ganglion, hypothalamus and ventral pons. In this report a patient with similar manifestation and having a cortical infarct in the territory supplied by superior division of middle cerebral artery[15].

CONCLUSION

The middle cerebral artery as described in conventional studies is the major source of blood supply to the Broca's area is found to be the major supply to this area in our study while the callosmarginal artery was found in 4% cases to be collateral artery to this area in our study which could explain the possible variable out come of cerebral infarcts with better progress in dual blood supply.

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