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A study of the anatomical variations in branching pattern of middle cerebral artery

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ABSTRACT

Background: Middle cerebral artery (MCA) is the largest and most complex arterial system of the brain. Variations of the aortic arch branches are due to alteration in the development of specific branchial arch arteries during the embryonic period. Knowledge of these variations is important during aortic instrumentation, thoracic, and neck surgeries. The anatomy of the anterior cerebral artery branches and the anterior communicating artery complex needs to be investigated individually to minimise neurovascular morbidity before iatrogenic procedures.

Aim: The study aimed to study the variations in the microsurgical anatomy of the MCA in our population and compare the variables and discuss their importance with anatomic and surgical considerations.

Materials and Methods: Specimens were collected from the embalmed cadavers and the post-mortem bodies in the department of forensic medicine of Thanjavur Medical College. The different variables regarding the MCA in our population were analysed and compared with the studies in the Western population and other Indian studies.

Results: The mean length of the MCA in this study was 12.8 mm with a standard error of 3.79 mm. The outer diameter of the M1 segment was with a mean length of 3.75mm. In 69.2% middle, Cerebral Artery shows bifurcation and in 20%, it shows trifurcation and in 10.8%, it shows ramification types of branching patterns. The 39.1% cases show Temporo polar, 21.7% orbitofrontal, 9.1% anterior temporal, 6.6% prefrontal, and 4.1% middle temporal branches. Our results also reveal that the origin of the lenticulostriate branch in the middle cerebral artery was 85.85% from the trunk and 14.2% from division, respectively.

Conclusion: MCA branching pattern is slightly higher in trifurcation pattern as compared to bifurcation and ramification. Thorough knowledge of the microvascular anatomy and the myriads of variations is essential for the operating surgeon to choose the ideal technique to avoid any catastrophe during and after surgery and give the best possible functional outcome.

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1. Introduction

The field of microsurgery has gone leaps and bounds over the years, which help better understand the normal anatomy and its intricate variations in the brain's vascular and other minute structures. Cadaveric microdissection is of immense help that forms our understanding of the intricate anatomy of the brain's structures. Of all the variations in the brain, vascular anatomy is the most fascinatingly

complex. The middle cerebral artery (MCA) is the largest and most complex arterial system of the brain. A solid understanding of the cerebral artery's normal anatomy, branching pattern, and distribution segment is required for the necessary interpretation of radiological images to plan the best treatment course.

The MCA divides into four main surgical segments, denominated M1 to M4.¹ The M1 segment is known as Sphenoidal, M2 as Insular, which runs in the lateral fissure; M3 capsular, which comes out from lateral fissure, and

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M4 as Cortical. The middle cerebral artery runs initially in the lateral; cerebral fissure and then posterosuperior to the Insula and then divides into branches.² According to MCA's branching pattern, the origin of cortical branches differs as orbital branches, frontal branches, parietal branches, and temporal branches. The point of bifurcation is the point of separation of MCA into two trunks. After this separation point, the artery gets separated into three (trifurcation), four (quadrifurcation), and multifurcation trunk, etc. It is also evident that in bifurcation patterns, the superior divisions always contain orbitofrontal and prefrontal, whereas the inferior divisions contain the temporo-polar, anterior temporal, and middle temporal.

According to West berg, 10-20 arterioles have origin in lateral two-thirds of the middle cerebral artery's sphenoidal segments from its posterosuperior edge and lies single or together as 1 or 2 or 3 main trunks.³ Jain 1964 has reported that perforating arteries arise in 54.1% from the trunk and 25.6% from the dividing point and 20.3% from the middle cerebral artery's cortical branch.⁴

Gibo et al. in 1981 found that branching patterns of the cortical vessels vary immensely. He stated that M1 segments typically encompass the entire Middle Cerebral artery stem and initial short segments of the post bifurcation or trifurcation division.⁵

Few studies are solely devoted to the anatomy of MCA. The present work aims to determine the morphological variations, branching pattern, symmetry, and morphometry of MCA in our population, compare the variables with the studies, and discuss their importance with anatomic and surgical considerations.

2. Materials and Methods

A total of 60 cadavers were studied in the department of Anatomy of Thanjavur Medical College. The study was started by undertaking the institutional ethical clearance.

During post-mortem examination of the cadavers, A skin incision was made in front of one ear to another ear in the coronal plane. The skin was reflected both anteriorly and posteriorly and the skull vault was removed as a single piece taking special care not to injure the dura.

A small Knick was made over the middle of each side of the frontal lobe. The durometer was divided into two halves with the help of non-toothed forceps. Followed it durometer was further divided into four flaps. The dura was opened from the frontal base in a transverse direction, and after cutting the flax, the frontal lobes were retracted slowly. The optic nerves were exposed and carefully cut along with the internal carotid artery (ICA) at their entrance into the cranial cavity. The brain was removed from the cranial cavity and preserved in 5% of formalin solution and numbered serially for further study. The specimen was soaked for 10–15 min in 10% formaldehyde solution. The internal carotid artery was identified and the origin of the middle cerebral artery was

traced by peeling off the diameter. An incision was made on the brain's lateral surface and the frontoparietal operculum was removed and the temporal lobe was pulled downward. MCA's M1 segment was carefully dissected, and the early branches from the superior aspect and the perforators from the inferior aspect were exposed.

3. Results

The 60 Specimens were dissected for anatomical study of the Middle Cerebral Artery in all the different samples. The branching patterns, the branches of MCA were carefully examined and the following observation was recorded.

The length of the M1 segment was found to be within the range of 5mm-20mm and above. The shortest length of the M1 segment was in the range of 5-7mm and the longest was 20mm and above, as shown in Table 1. The average mean length of the M1 segment was found to be 12.8mm with a standard error of 3.79mm.

Table 1: Distribution of the length of M1 Segment in all the sample studied

Length	No of Samples
20mm & above	7
17-19mm	8
14-16mm(normal)	40
11-13mm	30
8-10mm	25
5-7mm	10

The outer diameter of the M1 segment was found to be within the range of 3-5mm. No specimen had the outer diameter to be more than 5mm, as shown in Table 2. The average mean outer diameter of the M1 segment was 3.75mm with a standard error of 0.66mm.

Table 2: Distribution of outer diameter of M1 segment

Outer diameter of M1	No of samples
Above 5mm	-
3-5mm (normal)	105
Below 3mm	15

Table 3: The distribution of the branching pattern in the sample studied

Branching Pattern	No of Samples	Percentage
Bifurcation	83	69.2%
Trifurcation	24	20%
Ramification	13	10.8%

The different branching pattern arising from the stem, i.e. Temporo polar branching was seen in 39.1% Orbito Frontal in 21.7% Anterior Temporal in 9.1%, Prefrontal 6.6% and Middle Temporal in 4.1% of the total population as shown in Table 4.

Table 4: The distribution of the branching pattern in the sample studied

Branches	Number of Sample	Percentage
Temporo Polar	47	39.1%
Orbitol Frontal	26	21.7%
Anterior temporal	11	9.1%
Prefrontal	8	6.6%
Middle Temporal	5	4.1%

In the bifurcation pattern, it was observed that anterior Parietal arise in 73 specimens from superior division and 10 from inferior whereas in angular branching, 24 specimens arise from superior division and 59 from inferior division, and in posterior parietal 52 specimens shows superior division and 31 shows inferior division.

The pre-central branch shows the highest superior division in the trifurcation branching pattern, whereas the posterior parietal shows the highest in the middle division. Angular branching pattern arises highest from middle division and in Temporo occipital only middle and inferior division was observed in all the specimens as shown in Table 5.

Table 5: Branching pattern of superior, middle and inferior distribution

Branch	Superior	Middle	Inferior
Precentral	95.8%	4.2%	-
Posterior parietal	-	100%	Nil
Angular	-	83.3%	16.7%
Temporo Occipital	-	62.5%	37.5%

In lenticulostriate trunk were shown in 85.5% whereas division pattern was shown in 14.2% as shown in Table 6.

Table 6: Distribution of trunk and other division in the study group

Branches	Trunk	Division
Lenticulostriate	85.8%	14.2%

4. Discussion

The evolution of micro neurosurgery and the awareness of the arrangement of tiny perforating features vessels at the base of the brain have markedly and significantly improved the outcome and quality of the life of the patients subjected to surgery related to the vascular structures of the brain.

The different variables about the MCA in our population were analysed and compared with the Western population studies and another Indian study concerning the anatomical perspectives and surgical considerations.

Boguslavsky, 1986 found that one-tenth of patients with an ischemic stroke had an infarction of the middle cerebral

artery. One-third of the patients have complete involvement of the Middle cerebral artery.⁶

The middle cerebral artery (MCA) is the larger terminal branch of the internal carotid artery (ICA). The middle cerebral artery is the largest and the most elaborate of the intra Cerebral vessels. The middle cerebral artery supplies almost the brain's entire convex surface, including the lateral frontal, parietal, temporal lobes, Insula, Claustrum, and external capsules. 12 Cortical branches arise from the MCA stem in a variety of patterns. It is also well stated that M1 is composed of 2 components. The first is the undivided middle Cerebral artery stem from which the lenticulostriate branches arose. It occupies most of the length of this segment. The second component of the short segments from the bifurcation of MCA is divided into Sylvian fissure. The M2 segment has a bifurcation pattern (78%), trifurcation pattern (21%) and ramification pattern (10%).

According to Mohr, JM Benrentt, Stein in 1992, in bifurcation pattern, the superior division always contains orbitofrontal and prefrontal. The inferior division contains the tempora-polar, anterior and temporal, and middle temporal. The central branch is always in the upper division, while the posterior tempora is always in the upper division.⁷

Varder Fecken in 1961 found that the orbitofrontal and anterior temporal branches may arise from a common trunk.⁸ Umansky in 1988 studied the perforating branches of MCA and stated that four to five perforating branches originate from the main trunk of MCA before its division. The remaining vessels arise 8.5% from superior trunk vessels, 6% from the inferior trunk and 0.8% from the middle trunk, 5.3% from an early temporal branch and 0.4% from an early frontal branch.⁹ It is also stated that when the middle Cerebral artery trifurcates, superior division contain orbitofrontal and prefrontal and even pre-central.¹⁰

In our study of the trifurcation pattern, the orbitofrontal and prefrontal and percental branches arise in the upper division. The middle division is made up of the central, anterior parietal, and angular branches. The inferior division contains the temporo polar, anterior temporal, and middle temporal branches.

We also found that in trifurcation, the smallest and shortest branch supply the frontal lobe. In our study, temporo-polar was found to arise from the main stem in 39.1%, anterior temporal in 9.1%, middle temporal in 4.1%, orbitofrontal in 21.7% and prefrontal in 6.6% arise proximal to the main division.

5. Conclusion

The study of MCA showed some significant variations. As reported in earlier literature, the length and diameter of the M1 segment were within the normal range. Branching patterns show bifurcation in 69.2% and trifurcation in 20% and ramification in 10.8%, showing a slightly higher incidence of trifurcation pattern. Orbitofrontal branch arose

from main trunk 21.7%, which is higher than that reported in the previous study. Anterior parietal branch arises from superior division in 87.95% and inferior division in 20.05%. The posterior parietal branch arose from superior division I 62.25% and from inferior division in 37.35%. Accessory MCA or duplication of MCA is a rare phenomenon, and they do not have a specific cortical supply; hence they can be sacrificed if necessary. Awareness of these anatomical variations in branching patterns is important in neurovascular procedures. As very few anatomical studies on MCA are there in the literature, several scientists from a different region of the world should be done on a large scale to establish MCA's overall significance.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare that there is no conflict of interest.

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