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Original Article

Morphological and Morphometric Study of Branching Pattern of M2 Segment of Middle Cerebral Artery in Human Cadaveric Brains

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Abstract
Introduction & Aim: *The middle cerebral artery arises from the internal carotid artery as the terminal branch. It runs in the stem of lateral fissure as M1 segment and then on the insula as M2 segment with branches. The adjacent opercular cortex supplied by M3 and M4 segment. The aim of study was to record variations in branching pattern of middle cerebral artery in reference to insular cortex.*
Material & Method: *Formalin fixed 29 brains (58 right and left cerebral hemispheres) were studied at department of Anatomy, Gandhi medical college Bhopal. In the sylvian fissure the branching pattern and variations of middle cerebral artery observed. With the help of Digital Vernier Caliper and magnifying glasses the lengths of M1 & M2 segments recorded.*
Result: *The bifurcation pattern was present in 96.55% (56/58) cerebral hemispheres. The Mean length of the M1 segment of middle cerebral artery right side 14.63 ± 2.16 mm & left side 15.73 ± 2.54 mm. & M2 segment of middle cerebral artery superior trunk, right side 41.41 ± 8.48 mm, left side 40.18 ± 9.65 mm. and Inferior trunk, right side 49.63 ± 9.67 mm, left side 49.17 ± 9.71 mm.*
Conclusion: *Bifurcation is more common than trifurcation and the Mean length of Inferior trunk was more than superior trunk in both right and left side. In case of acute middle cerebral artery infarction, the blood supply of insular cortex gets affected and results in diagnostic radiological sign.*
Keywords: *morphology, morphometric, M2 segment middle cerebral artery, superior and inferior trunk, insular cortex.*

Introduction

The middle cerebral artery (MCA) is one of the three major paired arteries that supplies blood to the cerebrum.[1]The middle cerebral artery arises from the internal carotid as the larger terminal branch.[2] At first, it runs in the lateral fissure, then posterosuperiorly on the insula, and divides into branches distributed to the insula and the adjacent lateral cerebral surface. It also supplies blood to the anterior temporal lobes and the insular cortex.[3,4]

Middle cerebral artery MCA can be divided into the following four segments, M1 segment runs horizontally in the sylvian fissure, lies in sphenoidal compartment. M2 segment runs vertically on the surface of the insula and lies in operculoinsular compartment. M3 segment running laterally and exiting the insular cistern is cortical segment. M4 Segment, comprises the distal cortical branches.[1,5]

Insular cortex is predominantly supplied by M2 segment of Middle cerebral artery. The M3 segment also supply the extreme capsule and occasionally the claustrum and external capsule. Few branches from the M1 segment supply the limen insula.[1,6]

M1 segment bifurcation is more common than single trunk and trifurcation. M2 segment from limen insula to opercular cortex gives superior and inferior trunk with occasional presence of middle trunk. There are many branches of trunks and according to occurance of more number of branches, the dominance of trunk is decided. The dominant is the trunk with more branches than other trunk. Thus various morphological branching patterns of M2 segment of middle cerebral artery are; Bifurcation with Superior trunk and Inferior trunk equal dominance, Bifurcation with Superior trunk more dominant than Inferior trunk, Bifurcation with Inferior trunk more dominant than Superior trunk , Trifurcation and Multiple trunk 4 to 6 trunks of M2 segment.[1,7,8]

The main trunk divides in a bifurcation in 78% of hemispheres, in a trifurcation in 12% and in a multiple branch pattern in 10 %. The trifurcation is when the main trunk divides into superior, middle and inferior trunks. These trunks give rise to the lenticulostriate, orbitofrontal, prefrontal, precentral, central, anterior parietal , posterior parietal, angular, temporo-occipital, posterior temporal, middle temporal , anterior temporal and temporo-polar arteries.[9,10]

A. Bifurcation with equal trunks in 18% of hemispheres .The main trunk divides into superior and inferior trunks that are of approximately the same diameter and supply cortical areas of similar size. The superior trunk gives rise to the orbitofrontal arteries through the angular arteries and the inferior trunk gives rise to the temporo-polar through the temporo-occipital arteries.
B. Bifurcation with inferior trunk dominant in 32% of hemispheres. The inferior trunk has a larger diameter and area of supply than the superior trunk. The superior trunk supplies the orbitofrontal through the anterior parietal areas and the inferior trunk supplies the posterior parietal through the temporo-polar areas.
C. Bifurcation with superior trunk dominant in 28% of hemispheres. The superior trunk has a larger diameter and area of supply than the inferior trunk. It supplies the orbitofrontal through the temporo-occipital areas, and the inferior trunk supplies the temporal areas except for the temporo-polar area, which is supplied by an early branch, that arises from the main trunk.
D. Trifurcation pattern in 12 % of hemispheres. The main trunk of the MCA divides into three trunks. The superior trunk supplies the orbitofrontal and prefrontal and prefrontal areas, the middle trunk supplies the precentral through the posterior parietal areas.[1,3]

M 2 segment divides into superior and inferior trunk (Bifurcation is most common pattern). Superior trunk supplies the Anterior lobule of insular cortex and it contains short gyri. Inferior trunk supplies the Posterior lobule of insular cortex and it contains long gyri.[1] The insular cortex involvement is a marker of middle cerebral artery occlusion. The Insular ribbon sign on early CT scan can diagnose this stroke. The cases of post stroke arrhythmias, loss of thermal sensation and apraxia of speech all were reported in previous researches are directly indicate relation of insula and middle cerebral artery.[12]

Hence this study is conducted to analyze morphometric and morphological branching patterns of M2 segment of Middle cerebral artery in human cadaveric brains in Bhopal regions .That will be useful for neurosurgeons, neurophysicians and Interventional radiologists.

Material and Methods

This study was done in formalin fixed 29 brains (58 right and left cerebral hemispheres) with intact arachnoid matter, all segments of sylvian fissure, gyri and sulci of insular cortex and branches of all segments of middle cerebral artery. The study was approved by Scientific Review and Institutional Ethics Committee, Gandhi Medical College, Bhopal (M.P.).

The formalin fixed brains satisfying inclusion criteria were dissected and studied. In order to expose and visualize the Middle cerebral artery and its M2 segment branches over insular region, the arachnoid and piamater over the sylvian fissure specially operculoinsular compartment, was removed. The morphological analysis was done according to Rhoton et al[1]in which bifurcation, trifurcation and multiple trunks patterns were observed. The dominance of trunk was decided by more number of branches of trunk. According to Rhoton et al (2003),the branching Pattern of Middle cerebral artery, A=Bifurcation with Superior trunk and Inferior trunk equal dominance, B= Bifurcation with Inferior trunk more dominant than Superior trunk. C= Bifurcation with Superior trunk more dominant than Inferior trunk, D=Trifurcation and E=Multiple trunk 4 to 6 trunks of M2 segment. The long and short insular arteries of trunks of middle cerebral artery were observed with the help of magnifying glasses.

The lengths of M1 and M2 segments (superior trunk and inferior trunk) were measured with the help of thread, artery forceps and Digital Vernier caliper (sensitivity 0.1mm). Statistical analysis of results and comparisons among right and left hemispheres was done and Mean , SD, p value , Unpaired T test , Degree of freedom , SED , and r value Pearson correlation coefficient were analyzed and recorded.

Inclusion Criteria

Undamaged specimens of both right and left sided cerebral hemispheres cadaveric brains with intact Insula and sylvian fissure, middle cerebral artery branches over this particular area of concern.

Exclusion Criteria

Damaged specimens of cerebral hemispheres or damaged Insula and sylvian fissure, middle cerebral artery branches over this particular area of concern. Infant and Pediatric age group.

Observation & Result

In our study branching patterns of the Middle cerebral artery shows bifurcation as the most common branching pattern. The main trunk divides in a bifurcation in 56/58(96.6%) cerebral hemispheres, trifurcation in 1 /58(1.7%) cerebral hemisphere and in multiple trunk in 1 /58(1.7%) cerebral hemisphere. Bifurcation into superior trunk and inferior trunk with equal dominance in 10/58(17.24%) cerebral hemispheres. Bifurcation into superior trunk more dominant than inferior trunk in 20/58(34.5%) cerebral hemispheres. Bifurcation into inferior trunk more dominant than superior trunk in 26/58(44.85)cerebral hemispheres.

The length of the M1 segment of middle cerebral artery (right side) ranged from 10.81 to19.40 mm. with mean of 14.63 ± 2.16 mm. M1 segment of middle cerebral artery (left side) ranged from 11.40 to 20.31 mm. with mean of 15.73 ± 2.54 mm. M2 segment of middle cerebral artery (superior trunk) (right side) ranged from 32.82 to 69.50 mm. with mean of 41.41 ± 8.48mm. M2 segment of middle cerebral artery (superior trunk) (left side) ranged from 25.31 to 67.00 mm. with mean of 40.18 ± 9.65 mm. M2 segment of middle cerebral artery (Inferior trunk) (right side) ranged from 32.14 to 68.80 mm. with mean of 49.63 ± 9.67 mm. M2 segment of middle cerebral artery (Inferior trunk) (left side) ranged from 31.92 to 69.90 mm. with mean of 49.17 ± 9.71 mm.

As $p > 0.05$, for comparing the lengths of M1 & M2 segment of middle cerebral artery on both right and left side that indicates there is no significant difference between right and left side. As the p value is < 0.05 it explains the values are statistically significant for the comparison between lengths of superior and inferior trunks of M2 segment of middle cerebral artery on all 29 right side cerebral hemispheres the mean is 41.41 ± 8.48mm and49.63 ± 9.67 mm respectively. It indicates on right side mean is larger of inferior trunk. As the p value is < 0.05 it explains the values are statistically significant for the comparison between the lengths of superior and inferior trunks of M2 segment of middle cerebral artery on all 29 Left side cerebral hemispheres the mean is 40.18 ± 9.65 and 49.17± 9.71 respectively. It indicates on left side mean is larger of inferior trunk.

Table- 1: Middle Cerebral Artery Morphology

S. No.	Morphological Parameter	Number & Percentage		
		Rt.	Lt.	Total
1	ST = IT Bifurcation (Trunk equal)	4/29 (13.8%)	6/29 (20.7%)	10/58 (17.24%)
2	ST > IT Bifurcation (Superior trunk dominant)	9/29 (31.03%)	11/29 (38%)	20/58 (34.5%)
3	ST < IT Bifurcation (Inferior trunk dominant)	15/29 (52%)	11/29 (38%)	26/58 (44.85%)
4	Trifurcation	0	1/29 (03.3%)	1/58 (01.7%)
5	Multiple trunk	1/29 (03.3%)	0	1/58 (01.7%)

Table- 2: Middle Cerebral Artery Morphometry

S. No.	Middle Cerebral Artery Segment	Side	Minimum (mm)	Maximum (mm)	Mean (mm)	SD	P	t	SED
1	M1	Rt.	10.81	19.40	14.63	2.16	0.0811	1.7766	0.619
2	M1	Lt.	11.40	20.31	15.73	2.54			
3	M2 - Superior trunk	Rt.	32.82	69.50	41.41	8.48	0.6082	0.5156	2.386
4	M2 - Superior trunk	Lt.	25.31	67.00	40.18	9.65			
5	M2 - Inferior trunk	Rt.	32.14	68.80	49.63	9.67	0.8572	0.1808	2.545
6	M2 - Inferior trunk	Lt.	31.92	69.90	49.17	9.71			

Table- 3: Comparison of Lengths- Superior Trunk and Inferior Trunk on Right Side

S.No.	Middle Cerebral Artery M2 Segment	Side	Min. (mm)	Max. (mm)	Mean (mm)	SD	p	T	SED
1	Superior trunk	Rt.	32.82	69.50	41.41	8.48	0.0011	3.4417	2.388
2	Inferior trunk	Rt.	32.14	68.80	49.63	9.67			

Table-4 : Comparison of Lengths Superior Trunk and Inferior Trunk on Left Side

S No.	Middle Cerebral Artery M2 Segment	Side	Min. (mm)	Max. (mm)	Mean (mm)	SD	p	t	SED
1	Superior trunk	Lt.	25.31	67.00	40.18	9.65	0.008	3.5364	2.542
2	Inferior trunk	Lt.	31.92	69.90	49.17	9.71			

Discussion

Rhoton and Tanriover et al (2004), Ring et al and Lima et al also studied the branching patterns of the Middle cerebral artery on cadaveric brains.[3,9,10] Their results indicate bifurcation is most common pattern and correlates with our study.

Accessory MCA was found in seven specimens (2.05%). Duplicated MCA was seen in three specimens (0.88%). Aneurysm was found in three specimens (0.88%). MCA with bifurcated, trifurcated, quadrifurcated and single trunk termination was seen in 220 (64.70%), 42 (12.35%), 8(2.35%), and in 70 (20.58%) specimens respectively, Bifurcated pattern as upper prominent trunk (type A), lower prominent trunk (type B) and both equal prominent trunks (type C) were seen in 63 (28.63%), 129 (58. 63%), and 28 (12.72%) specimens respectively. Asymmetry was seen in 102 specimens (60%). Mean length and diameter of the MCA was 25.5-27.8 mm and 3 mm respectively.[11]

The review included all segments of middle cerebral artery (M1, M2, M3, M4).[13] The branching pattern prevalence correlates with our study regarding bifurcation and trifurcation. Previous studies differs with our study in terms of monofurcation and tetrafurcation cases related findings. As according to Ogeng'o et al (2011)18/288 (6.3%) cases of monofurcation and 2/288 (0.7%) cases of tetrafurcation were reported. According to Sadatomo et al (2013), the bifurcation cases 115/124 (92.7%) and trifurcation cases 9/124 (7.3%), indicates bifurcation as most common pattern. Reported length of MCA & M1 segment was 10 to 38 mm & 10 to 30 mm respectively.[13] The length of M1 segment 30 mm, Lumen size 6 mm. Mostly M1 segment shows bifurcation and in 4% trifurcation.[14] Sickle cell anemia, carcinoma and cases of pediatric strokes need computationl fluid dynamics analysis in the middle cerebral artery. If the length of M2 segment was improper then post-operative healing delay and motor deficit cases were reported.[15] Resection of insular opercular glioma require intra operative motor evoked potential monitoring (MEPM) through long insular artery, so M2 segment length measurements are significant. Preservation of the long insular artery to prevent postoperative motor deficits (insular cortex lesion) needs knowledge of normal and variable branching pattern of M2 segment .[16,17] However the comparision of lengths of middle cerebral artery trunks and their reference with insula discussed, which can be of great clinical significance.

Conclusion

In the present study we conclude Bifurcation is more common than trifurcation. In the case of acute middle cerebral artery infarction the blood supply of insular cortex get affected then loss of definition of the gray white interface in the lateral margin of insula considered as radiological sign. Acute Middle cerebral artery Infarct represents Insular ribbon sign on early CT Scan. There is correlation of lengths of trunks of middle cerebral artery and lengths of insular cortex gyri. The lengths of posterior lobule gyri of insular cortex are more than anterior lobule gyri of insular cortex. The Mean length of Inferior trunk was more than the Mean length of superior trunk in both right and left side.Awareness of these anatomical variations in branching patterns is important in neurovascular procedures.Thus outcome of this study will be helpful to neurosurgeons, neurophysicians and Interventional Radiologists.

References

1. Albert Rhoton; Cranial anatomy and Surgical Approaches, Neurosurgery. Rhoton's Anatomy, volume 53,part 2, October 2003, page 26 – 156
2. Peele T.L; The neuroanatomic basis for clinical neurology 2nd edition. McGraw Hill, Blackstone Division , London 1961.
3. Tanriover N, Kawashima M. Rhoton Jr A et al. Microsurgical anatomy of the insula

and sylvian fissure. J Neurosurg. 2004-May 100(5):891922
4. Ture U, Yasargil MG. AI-Mefty O, Yasargil DCH. Arteries of the insula. Neurosurgery 2000; 92:676-687
5. Standring S. Gray's Anatomy. Arterial Supply of Brain. 40th ed. Spain: Elsevier Ltd.; 2008:250.
6. Osborn AG: Diagnostic Neuroadiology, ed I. St. Louis: Mosby, Inc, 1994, pp 136-138.
7. Yasargil MG. Middle Cerebral Artery Microneurosurgery. Vol I. New York: Georg Thieme Verlag: 1982:72.
8. Kiernan JA, Blood Supply of the central nervous system. In: Kiernan JA, Ed. In: Barr's the Human Nervous System: An Anatomical Viewpoint. Philadelphia: Lippincott-Raven: 1998:439-455.
9. Ring BA. Middle cerebral artery: anatomical and radiographic study. Acta Radiol. 1962:57(4):289-300.
10. Lima P. Cerebral Angiography. New York: Oxford University Press: 1950.
11. Pai SB, Varma RG, Kulkarni RN. Microsurgical anatomy of middle cerebral artery. Neurology. 2005:53:186-190.
12. C Cereda, J Ghika, P .Maeder .Strokes restricted to the insular cortex. Neurology December 24, 2002; 59 (12). L6
13. Karen Cilliers, Benedict John PAGE. Anatomy of the Middle Cerebral Artery: Cortical Branches, Branching Pattern and Anomalies. DOI: 10.5137/1019-5149.JTN. 18127-2016
14. S Sundari et al. Branching Pattern of Middle Cerebral Artery IJSR ISSN: 2319-7064,Volume 5 Issue 11, November 2016.
15. CP Rivera, A Veneziani RE Ware. Original Research sickle cell anemia and pediatric strokes – computationl fluid dynamics analysis in the middle cerebral artery —biology and medicine, 2016.
16. Tamura A, Kasai T, et al.Long insular artery infarction: characteristics of a previously unrecognized entity. AJNR Am J Neuroradiol. 2014. Mar; 35(3): 466-71.
17. Preservation of the long insular artery to prevent postoperative motor deficits after resection of insular – opercular glioma: Technical Case reports. Neurol Med Chir (Tokyo). 2014 April; 54(4): 321-326.