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Review Article

Review on Anatomy of Cerebral Arterial System- Clinical Importance

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Abstract

Cortical system and central system of arteries supply the entire cerebrum. The cortical branches supply the grey matter at the surface of the hemisphere and are derived from the anterior, middle and posterior cerebral arteries. The grey matter is more vascular than the white matter due to high metabolic rate. The central system of arteries derived from the circle of Willies, penetrate the base of the brain and supply the diencephalon, basal nuclei and the internal capsule. Literatures stated central branches are end arteries for all practical purposes. Both the central and cortical branches are surrounded by periarterial pial sheath upto the precapillarylevel. The periarterial sheath is filled with cerebrospinal fluid and probably exerts damping effect on the expansile pulsation of artery. Supero- lateral surface of the hemisphere is supplied by middle cerebral artery, medial surface outside the corpus callosum is under nutritional control of the anterior cerebral artery. Posterior cerebral artery supplies the infero- medial surface of the occipital and temporal lobes including visual area. The arterial system is responsible for the constant nourishment and oxygenation of the brain, any disruption of the system will have almost immediate and potentially catastrophic consequences. Ischemic deficits, haemorrhagic events and structural anomalies associated with cerebrovascular diseases are the most common pathological conditions of cerebral arterial system.

Key words: Cortical system, Supero- lateral, cerebrovascular diseases .

Introduction

The cerebral arteries are derived from the internal carotid and vertebral arteries. The anastomosis between these arteries at the base of the brain is known as the arterial circle of Willis[1,2]. It is formed in front by the anterior cerebral arteries, branches of the internal carotid artery, which are connected together by the anterior communicating branches ; behind by the two posterior cerebral arteries, branches of the basilar artery, which are connected on either side with the internal carotid by the posterior communicating arteries (Figure-1&2).The lamina terminalis, the optic chiasma, the infundibulum, the tuber cinereum, the corpora mammillaria, and the posterior perforated substance are within this arterial anastomosis[3,4].

The three trunks which together supply each cerebral hemisphere arise from the arterial circle of Willis. From its anterior part proceed the two anterior cerebral arteries, from its antero-lateral parts the middle cerebral arteries and from its posterior part the posterior cerebral arteries [5]. These principal arteries give origin to two different systems of secondary vessels. They are ganglionic system of vessels to supply the thalami and corpora striata and the cortical system of vessels which are ramify in the pia mater and supply the cortex and subjacent brain substance [6]. These two systems do not communicate at any point of their peripheral distribution, but are entirely independent of each other. The parts supplied by the two systems are borderland of diminished nutritive activity, where softening is especially liable to occur in the brains of old people [7,8].

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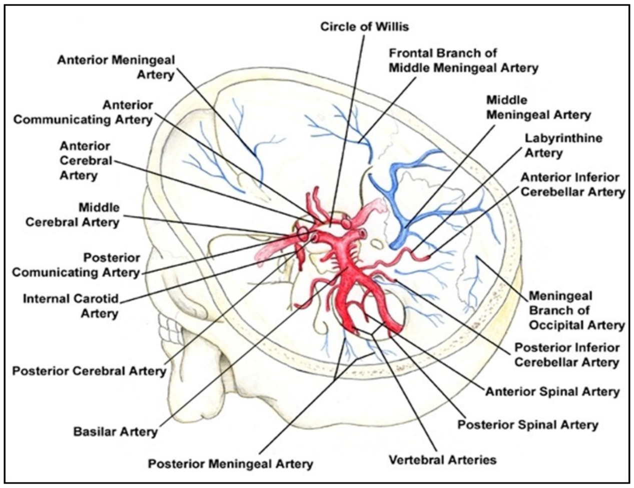

Figure – 1: Arterial circle of Willies at the base of the brain

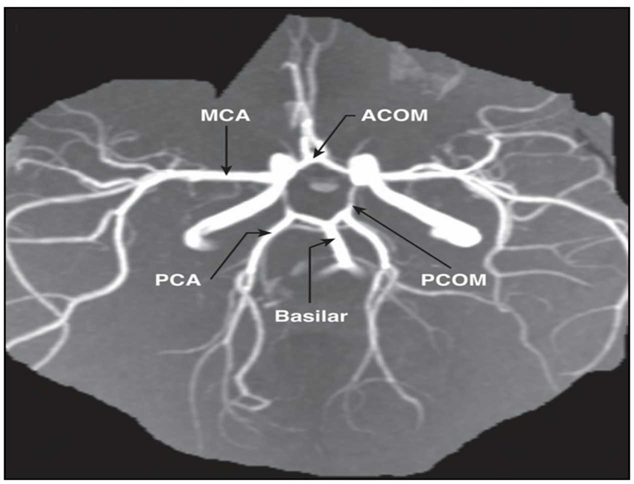

Figure – 2: Magnetic Resonance Imaging Arteriography showing Arterial circle of Willis (MCA: Middle cerebral artery ;PCA: Posterior cerebral artery; ACOM: Anterior communicating ;PCOM: Posterior communicating branch; Basilar artery).

Ganglionic System

All the vessels of this system are given off from the arterial circle of Willis or from the vessels close to it [9]. They form six principal groups antero-medial group, derived from the anterior cerebral arteries and anterior communicating branch; postero-medial group, from the posterior cerebral arteries and posterior communicating branches; Right and left antero-lateral groups, from the middle cerebral arteries; Right and left postero-lateral groups, from the posterior cerebral arteries around the cerebral peduncles(Figure-3).

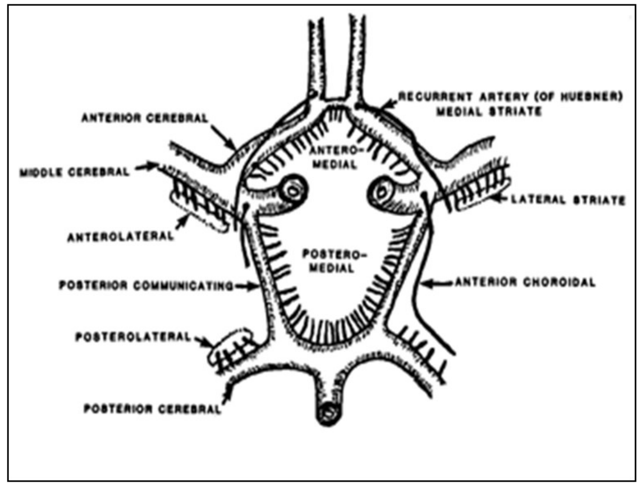

Figure – 3: Ganglionic and Cortical arterial system of cerebral arteries.

The vessels of this system are larger than those of the cortical system and also called as tertiary arteries by means of vessels which from their origin to termination neither supply nor receive any anastomotic branch [10.11]. Through these vessels a limited area of the thalamus or corpus striatum can be injected, and the injection cannot be driven beyond the area of the part supplied by the particular vessel which is the subject of the experiment.

Cortical Arterial System

The terminal branches of the anterior, middle, and posterior cerebral arteries form the cortical system [2, 12]. They divide and ramify in the substance of the pia mater, and give off branches which penetrate the brain cortex, perpendicularly [13,14].These branches are divisible into two types like long and short. The long or medullary arteries pass through the gray substance and penetrate the subjacent white substance to the depth of 3 or 4 cm, without intercommunicating others and thus constitute so many independent small systems. The short vessels are confined to the cortex, where they communicate with the long vessels to form compact net-work in the middle zone of the gray substance, the outer and inner zones being sparingly supplied with blood [15]. Vessels of the cortical arterial system are not terminal arteries like ganglionic system, but their approach is very close to this type , so that injection of one area from the vessel to other area is not much difficult but possible in the vessels of small calibre[2,15]. As a result, obstruction of one of the main branches, or its divisions, may have the effect of producing softening in a limited area of the cortex.

Role of Specific Anatomic Features of Cerebral Arterial System in Pathophysiology of Cerebral arterial variations and their clinical complications

The blood supply of the brain are particularly significant because neurons are more sensitive to oxygen deprivation, brain tissue deprived of oxygen and glucose as a result of compromised blood supply is likely to sustain transient or permanent damage[16]. Brief Ischemia (Lack of blood supply) can cause cellular changes, if not quickly reversed which may lead to cell death [17,18]. Sustained Ischemia leads to death and degeneration of the deprived cells. Stroke refers to the death or dysfunction of brain tissue due to vascular disease, often follow the occlusion of the brain's arteries. In addition, the brain is at risk from circulating toxins, and is specifically protected in this respect by the blood-brain barrier [19,20]. Historically, studies of the functional consequences of strokes, and their relation to vascular territories in the brain and spinal cord, provided information about the location of various brain functions [21]. Now, non-invasive functional imaging techniques based on blood flow have largely supplanted the correlation of clinical signs and symptoms with the location of tissue damage observed at autopsy [18,21].

Conclusion and future perspective

Anatomical variations of circle of willis and its constituent vessels are important in clinical and surgical approaches. Magnetic resonance imaging of arteriograms are useful in diagnosis of cerebrovascular diseases [19]. Preliminary anatomical knowledge and incidences of vascular variations of brain help us as future prospective in understanding vascular pattern. Structural anomalies like intracranial arterial fenestrations, internal carotid arteries absence and aberrant nature and also anterior, middle and posterior cerebral arterial variations provide clinical knowledge to the surgeons before planning neurovascular surgeries.

References

1. John E. Mendoza, Anne L. Foundas. The Cerebral Vascular System. Clinical Neuroanatomy: A Neurobehavioral Approach .2008, pp; 501-543.
2. Duvernoy HM,Delon S,Vannson JL:cortical blood vessels of the human brain. Brain res Bull 7;1981;PP:519-579.
3. A.K.Datta. Blood supply of the Brain. Essentials of Human Neuroanatomy.4th Edition.ISBN;81-86793-88-7.PP;182-195
4. Henry Gray and Warren Harmon. The Arteries of the Brain .Text book of Anatomy of the Human Body. 1918. ISBN No: 1-58734-102-6.PP; 1396.
5. Lee RM. Morphology of cerebral arteries. Pharmacol Ther. 1995; 66: pp. 149–173.
6. Jones EG. On the mode of entry of blood vessels into the cerebral cortex. J Anat. 1970; 106: pp. 507–520.
7. Brust JCM, Chamorro A. Anterior cerebral artery disease. In: Mohr JP, Choi DW, Grotta JC, Weir B, Wolf PA, editors. Stroke: Pathophysiology, Diagnosis and Management. 4th Ed. London, UK: Churchill Livingstone; 2004. pp. 101–122.
8. Mohr JP, Lazar RM, Marshall RS, Hier DB. Middle cerebral artery disease. In: Mohr JP, Choi DW, Grotta JC, Weir B, Wolf PA, editors. Stroke: Pathophysiology, Diagnosis and Management. 4th Ed. London, UK: Churchill Livingstone; 2004. pp. 123 –166.
9. Baptista AG. Studies on the Arteries of the Brain. 3. Circle of Willis: Morphologic Features. Acta Neurol Scand. 1964;40:398-414.
10. Alpers BJ, Berry RG, Paddison RM. Anatomical studies of the circle of Willis in normal brain. AMA Arch Neurol Psychiatry. Apr 1959;81 (4):409-18.
11. Grand W, Hopkins LN. Variations in Clinical Anatomy. In: Vasculature of the Brain and Cranial Base. New York: Thieme; 1999.
12. Klapecki J, Pacholec E, Ciszek B, Anatomy of the posterior communicating artery - preliminary report, Folia Morphologica, Vol. 55, pp.335-337, 1996.
13. Kwolek-klimkiewicz, J., Ciszek, B., Aleksandrowicz, R., Mazurowski, W., Zabek, M., Gorski, R.Microsurgical anatomy of the anterior communicating artery. Folia Morphologica, Vol. 55, pp.369-370, 1996.
14. Hilen,.,Hoogstraten,H.W.,Vanoverbeeke,J.J.,Van derzwan.A. Functional anatomy of the circulus arteriosus cerebri, Bulletin de 1'Association.1991.vol.75.pp 123-126.
15. Fitz Gerald, M. (1996) Neuroanatomy Basic and Clinical. Philadelphia: W.B. Saunders.
16. Pacholec, E.,Ciszek, B. Morphometry of the supraclinoid part of the internal carotid artery, Acta Clinica, Vol. 2, pp.96-101 2003.
17. Ryan S.P., Mc Nicholas M.M.J., Central Nervous system in Anatomy for diagnostic Imaging by W.B. Saunders Company Ltd. London. 1998, pp 77-80.

18. Krayenbuhl HA, Yasargil MG. Cerebral Angiography (2nd ed.). London: Butterworth 1968.
19. Krabbe-Hartkamp MJ, van der Grond J, de Leeuw FE, de Groot JC, Algra A, Hillen B, et al. Circle of Willis: morphologic variation on three-dimensional time-of-flight MR angiograms. Radiology. Apr 1998;207(1):103-11.
20. Liebeskind D.S. Collateral circulation,Stroke.2003.Vol.34;pp.2279-2284.
21. Hoksbergen A.W.J.; Fulesdi B., Legemate D.A, Csiba L. Collateral Configuration of the Circle of Willis. Transcranial Color-Coded Duplex Ultrasonography and Comparison With Postmortem Anatomy, Stroke, Vol. 31, pp.1346-1351, 2000.