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Original Article

Study of anomalies in the circle of Willis using magnetic resonance angiography in north eastern India

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ABSTRACT

Introduction: The circle of Willis is a large arterial anastomotic ring present at the basal cistern of the brain, uniting the internal carotid and the vertebrobasilar system. Branches from this arterial ring are distributed to supply the brain. In the year 1664, Sir Thomas Willis was the first to describe the importance of the circle in maintaining collateral flow. It was observed that there is very little mixing of blood between the collateral branches of the circle. These collaterals may however open up during occlusive episodes of the proximal feeding vessels. The anatomy of the circle is known to vary considerably and functionally a complete circle is a rare finding. This type of incomplete or variant forms off the circle may diminish its role as a collateral route.

Methods: The morphological pattern of circle of Willis of 70 healthy individuals from northeast India was studied retrospectively using Time of Flight-Magnetic resonance angiography (TOF-MRA).

Results: Only 17 (24.28%) MRA's presented with a complete (classic) circle of Willis. Most common variant observed in our study was unilateral hypoplastic posterior communicating artery (20%). Most common variant observed in the anterior circulation was unilateral hypoplastic A1 segment of anterior cerebral artery (11.42%).

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Discussion: Most of the variant forms observed were comparable with earlier established findings. This variability (rare patterns) can be distinguished from an anomalous architecture if correlated phylogenically and embryologically.

1. Introduction

The outcome of a neurovascular injury depends on the presence or absence of an adequate collateral flow during occlusive episodes of the feeding arteries. The availability of these collaterals or alternate routes further depends on the morphological pattern of an arterial circle supplying the brain known as the circle of Willis. The circle of Willis is formed by anastomosis between the internal carotid, pre-communicating part (A1) of anterior cerebral, anterior communicating; pre-communicating part (P1) of posterior cerebral and posterior communicating arteries (Fig. 1). The morphological pattern of this arterial circle supplying the brain is again known to vary. Usually the mean variability (largest population) of these vessels represents the mainstream of evolution. This variability is again limited by extreme variants, still compatible with a function, and although still "normal", they represent an increase rigidity of the system at its edges. The "anomaly" usually represents too much convergence or divergence. A minimal additional constrain will reveal its limited flexibility; thereafter, the anomaly becomes "abnormal" and symptomatic.[1] Therefore, it is seen that under normal circumstances embryological events like territorial transfer and sharing of territories between the adjacent developing vessels may results in normal circulation even in variant forms of the circle of Willis.[1] The situation becomes complicated only during occluding episodes of the feeders. The common variations encountered may be a result of developmental arrest during embryonic life as most of the branches are derived from the internal carotid, formed progressively from the third arch artery. Review of phylogeny and embryology usually gives the clues and helps to establish the limits of variability.[1] A few variations will be difficult to recognize unless one is familiar with prior disposition of the vascular tree in animals.[1] Without proper acquaintance of these variations diagnostic and neurosurgical procedure may become complicated. Knowledge of these anomalies enables distinction between hypoplasia and spasm and angiographic filling pattern can also be determined.[2] In our study, the various morphological patterns of the circle of Willis were observed and classified retrospectively using Magnetic resonance angiography (MRA) in healthy living individuals. MRA has enabled evaluation of the intracranial vessels without the need for invasive procedures like catheter angiography, avoiding small but definite risk of clinically silent embolism[3] complications like pseudoaneurysms, contrast associated reactions and vascular dissections are possibilities of catheter angiography. MRA can not reveal any arteries invisible in conventional angiography, but provides a specificity of 100%. The sensitivity of MRA was 89.2% for the anterior and 81.3% for the posterior communicating arteries and 100% for the anterior, middle and posterior cerebral arteries.[4] In view of such high specificity and sensitivity we undertake this retrospective study on the various morphological variations of the circle of Willis. Four methods for performing MRA are available which includes Time of Flight (TOF), phase contrast (PC), Black blood Imaging and contrast enhanced MRA or CE-MRA. We used TOF-MRA in the present study.

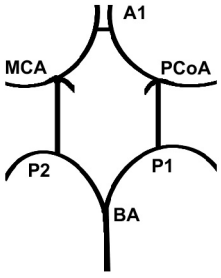

Fig. 1 – Schematic representation (vessels forming the circle of Willis) of the anterior part of the circle formed by the pre-communicating segments (A1) of the right and left anterior cerebral arteries (ACA) and an anterior communicating artery (ACoA) between them. The posterior part of the circle formed by the pre-communicating segments (P1) of the right and left posterior cerebral arteries (PCA), together with the right and left posterior communicating arteries (PCoA). The right and left PCoA's originate from the right and left internal carotid arteries (ICAs) The A2 and P2 segments are the post -communicating portions of the anterior and posterior cerebral arteries respectively. BA: basilar artery, MCA: middle cerebral artery.

2. Materials and method

In the present study the circle of Willis was studied in 70 living individuals retrospectively by using Time of Flight-Magnetic resonance angiography. The study includes subjects of all age groups and both sexes belonging to different communities in the northeast region of India. The study was conducted in the Department of Radiology, NEIGRIHMS, Shillong, Meghalaya, India, for a period from 10th April 2012 to 22nd November 2012. All the patients went under 3D TOF-MR Angiography using 1.5 T machine (Avanto, Siemens, Germany). Following imaging parameters were used repetition time/echo time 23/7.0, flip angle 25 °, slice thickness 0.7 mm, number of slice 44/slab,