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Original Research Article

A Study to Find the Association Between Gender and Anatomical Variation of Circle of Willis in Terms of Shape, Symmetry and Completeness

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Abstract

Aim: To provide some information regarding the anatomical variations circle of willis and its gender association.

Materials and Methods: The present observational study was conducted on 80 cadavers collected from voluntary body donation at the Department of Anatomy and Fresh corpses undergoing autopsy at the Department of Forensic Medicine, Hi-tech Medical College, Bhubaneswar, Odisha, India, from November 2016 –October 2018. The Circle of Willis of each brain was dissected carefully and a part of the base of the brain was cut and removed, if necessary, to expose the arterial circle clearly. The posterior communicating artery was observed carefully because it might be hidden by the thickened arachnoid mater. The length and circumference of different components of the Circle of Willis was measured. The circumference (perimeter) of artery was measured by a fine malleable copper wire. Photograph was taken and the detailed identity of the cadaver and its brain was marked. Whenever a circle revealed any gross deviations from what had been mentioned as normal in, it was represented by a free hand sketch or photograph.

Results: Out of 80 specimens, 62.5% were male and 37.5% were female. Mean age of the study specimens' was 54.19 years. The 'normal' circles 62.9% are male and 37.1% female; whereas, in 'variant' circles 61.1% are male and 38.9% female. Sex variation of circle of willis according to shape, completeness and symmetry reveals no statistically significant difference.

Conclusion: No significant variations are noted in either sex regarding shape, symmetry, completeness of the circle.

Keywords: circle of willis, gender, shape, symmetry, completeness

Introduction

A considerable part of brain is supplied by the branches of two vertebral arteries and two internal carotid arteries. A significant anastomosis, the circulous arteriosus, exists between the vertebral carotid arterial systems. Thomas Willis[1] (1621-1675), an English Anatomist as well as physician first described the presence of a circular arterial anastomosis at the base of the brain. Hence the arterial circle is commonly termed as "Circle of Willis". Since then this arterial circle goes by his name as the 'Circle of Willis' and was published in 'Ceribri Anatome' in 1664.The original illustrations of the circulous arteriosus incorporated in the above treatise of Willis was, however, made by sir Christofer Wren(1632-1723), an architectural genius and outstanding anatomist.

In the twentieth century much works have been done in different aspects of the arterial circle of will is including its embryological and angiographical aspects, But its study on the Indian subjects is too meager.

Schaeffer, J.P.[2] (1942) in "Morris' Human Anatomy" mentioned that the shape of the arterial circle of willis is circular or hexagonal in nature and there exists various anomalies in different components of Circle of Willis, likely the posterior communicating artery may arise from the middle cerebral artery; it is usually slender but may be of considerable size and the portion of posterior cerebral artery between the basilar and the posterior communicating artery being then as a rule is reduced to a mere rudiment. Martinez et al [3], 2004, mentioned that some of them are associated with vascular malformations such as aneurysms. Standring [4], 2005, illustrate that Circle of Willis is in fact polygonal than circular.

Cerebrovascular diseases, internal carotid artery occlusion, unilateral flow-restrictive extra cranial carotid artery disease together with their signs and symptoms grossly depend upon the variations of the anatomical pattern of Circle of Willis. (Baumgartner et al,1996 and 1997, Hartkamp et al, 1999; Kluytmans et al, 1999; Emsley et al, 2006) [5,6,7,8,9].

Nevertheless, there is no gainsaying of the basic fact that many a riddle encountered during the course of investigation for the assessment of function and applied significance of an anatomical entity can often be dispelled by proper appreciation of some very simple gross anatomic features hitherto remaining unobserved. Hence the importance of gross anatomic study on the circle of willis cannot be overemphasized.

Hence, the aim of this study was to provide some information regarding the anatomical variations circle of willis based upon gender.

Materials and Methods

The present observational study was conducted on 80 cadavers collected from voluntary body donation at the Department of Anatomy and Fresh corpses undergoing autopsy at the Department of Forensic Medicine, Hi-tech Medical College, from November 2016 –October 2018.

Inclusion Criteria

- Cadavers of 20 -60 yrs.
- Cadavers with known identity.
- Cadavers with origin from India.

Exclusion Criteria

- Cadavers with head injury are excluded.
- Cadavers with improper preservation (especially brain) are excluded.

Study Tools

- 10% Formalin solution.
- Glass wool & large sized glass container.
- Forceps, scissors, gloves, bone-saw and other dissection instruments.
- Magnifying glass.

- Scale, measuring tape, thread and fine malleable copper wire.
- 3X zoom, 8 megapixel Nikon Digital Camera.
- Record form.

Method

The study was carried out after the approval of the Institutional Ethics Committee according to the above stated selection criteria.

The sex and age of the cadavers from which the specimens of the brain had been obtained, were noted. Using a scalpel, a circumferential incision was made around the scalp. After pulling the whole thing, it was cut as high as possible. Then by a bone –saw the bone of the calvarium and a wedge of the occipital bone was removed. After reflecting the dura mater the spinal cord, vertebral arteries, and superior spinal nerves were transected for careful removal of the brain. The brain was then kept in 10% Formalin for fixation. Each brain was placed over glass wool in separate container to avoid distortion. Arachnoid mater was probed and peeled away to reveal the arteries at the base of the brain. The Circle of Willis of each brain was dissected carefully and a part of the base of the brain was cut and removed, if necessary, to expose the arterial circle clearly. The posterior communicating artery was observed carefully because it might be hidden by the thickened arachnoid mater.The length and circumference of different components of the Circle of Willis was measured. The circumference (perimeter) of artery was measured by a fine malleable copper wire. Photograph was taken and the detailed identity of the cadaver and its brain was marked. Whenever a circle revealed any gross deviations from what had been mentioned as normal in, it was represented by a free hand sketch or photograph.

Needless to mention that the arterial circle of willis was considered to be normal, complete, symmetrical only when it conformed to the aforesaid “Standard anatomic description”. It is to be realized, however that the term ‘Normal’ means not a fixed point but a range. Hence, the circle of willis in question would be considered ‘normal’ only when their existed no gross or markedly conspicuous deviation from the “Standard description” in respect of shape and configuration of the said circle, or in other words, when no grossly apparent dissimilarities were revealed in the pattern and architecture of the different arteries and their branches taking part In the formation of this circle. Rest o of the specimen that were not following the aforesaid description were stamped as ‘variant or abnormal’. ‘Aplasia’ of component artery was defined as absence of artery by naked eye with magnifying glass after repeated meticulous examination. ‘Hypoplasia’ of component artery was defined as diameter less than 1mm. All such definitions are as per convention as well as previous and current literature support. In case of measuring the diameter and length of duplication or double Acom, after taking the length and diameter of individual Acom, average were finally taken. During measurement of the length of Pca, the segment from the bifurcation of basilar artery to the meeting point with the Pcom was taken. In some cases, where Pcom is absent, the measurement of length of that particular segment was not possible. For those cases length of the Pca was not measured. During statistical analysis, valid number of specimens was taken as per statistical principle.

Statistical Analysis

Software used for calculation were Statistica version 6 (Tulsa, Oklahoma: Stat soft Inc., 2001) and Medcalc version 11.6 (Mariakerke, Belgium: Med calc Software 11.6).

Results

Table 1: Distribution of the study specimens according age and gender

Variables	Male	Female
Gender (N=80)	50 (62.5%)	30 (37.5%)
Age (Mean, Median)	54.19 years, 56.0 years	

Out of 80 specimens, 62.5% were male and 37.5% were female. Mean age of the study specimens' was 54.19 years.

Table 2: Sex distribution in 'normal' and 'variant' specimens

Variability	n	Male	Female
Normal	62	39 (62.90%)	23 (37.10%)
Variant	18	11 (61.10%)	7 (38.90%)

The 'normal' circles 62.9% are male and 37.1% female; whereas, in 'variant' circles 61.1% are male and 38.9% female. There is no statistically significant sex variation between the two groups.

Table 3: Sex distribution in specimens according to shape and symmetry

Variables	n	Male	Female
Shape			
Heptagonal	73 (91.25%)	45 (56.25%)	28 (35%)
Other	7 (8.75%)	5 (6.25%)	2 (2.5%)
Completeness			
Complete	73 (91.25%)	45 (56.25%)	28 (35%)
Incomplete	7(8.75%)	5 (6.25%)	2 (2.5%)
Symmetry			
Yes	62 (77.5%)	38 (47.5%)	24 (30%)
No	18 (22.5%)	12 (15%)	6 (7.5%)

Sex variation of circle of willis according to shape (heptagonal or other). It reveals no statistically significant difference (p=0.706, by Fischer's exact test 2-tailed p, that is >0.05).

Sex variation regarding completeness of circle of willis. Applying appropriate statistical tests, no significant difference (by Fischer's exact test 2-tailed p >0.05) is found.

Sex according to symmetry of circle of willis which reveal no statistically significant difference (p=0.798, by Fischer's exact test 2-tailedp, that is >0.05).

Discussion

The prevalence of the 'typical or classic circle', the "normal" textbook polygon ranges from 4.6% [70] to 72.2%.[10] A possible reason for the wide range may be the diversity in nomenclature and the criteria used to define hypoplastic vessels. There is little unanimity in nomenclature and quantitative measurement of the diameters of all the

component vessels of 'circle', which has not been measured in several studies and has relied upon rough estimations of the vessel diameter in determining the anomalies of the CW rather than actual measurements. Vessels have been described as 'thread-like', 'string-like', 'minute', and 'very small' without regards to measured diameter.

In the present study, out of 80 specimens, 62.5% were male and 37.5% were female. The 'normal' circles 62.9% are male and 37.1% female; whereas, in 'variant' circles 61.1% are male and 38.9% female. There is no statistically significant sex variation between the two groups. Sex variation of circle of willis according to shape (heptagonal or other). It reveals no statistically significant difference (p=0.706, by Fischer's exact test 2-tailed p, that is >0.05). Sex variation regarding completeness of circle of willis. Applying appropriate statistical tests, no significant difference (by Fischer's exact test 2-tailed p >0.05) is found. Sex according to symmetry of circle of willis which reveal no statistically significant difference (p=0.798, by Fischer's exact test 2-tailedp, that is >0.05). Not so much studies have been conducted over the time for confirming the significant difference in variations between two sexes. El Khamlichi et al.[11] had studied 31 female and 69 male cases without getting any statistically significant difference in variation between two sexes. Macchi et al.[12] in his magnetic resonance study in 100 healthy subject (50 male, 50 female) found no statistically significant difference between the frequency of variations between either sex. In another MRA study the author observed sex linked statistically significant difference in anatomical variations of the circle of willis. Their observations are different to the current study and Macchi et al.[12] So gender may be one of the potential sources of difference but we cannot comment on its role considering the available data.

So far as the shape or configuration of the arterial circle of willis is concerned, no specimen under the present study revealed an arterial circle in the truest sense of the term, instead, 91.25% presented an arterial anastomosis conforming to a heptagon (a plane figure with seven angle and sides), that is, a polygon (a plane figure of more than four angles and sides). Hence the present study corroborates fully with the statements of Thorek[13] (1951), who mentioned unequivocally that the anastomosis in question is heptagonal in nature; it also corroborates the statement of Gardener et al.[14] (1963) and Romanes[15] (1964) who mention that the said anastomosis conforms to a polygon. It is relevant here to point out the view of earlier workers regarding the same; Shaeffer[16] (1942) described the arterial anastomosis as circular and heptagonal, Hollinshead[17] (1967) and Anson et al.[18] (1971) as hexagonal, Truex et al.[19] (1970) as circular or heptagonal and Warwick et al.[20] (1973) as more polygonal than circular. Last[21] (1959) mentions it more accurately, the polygon of willis. In view of the present observations it may quite appropriately be called a 'heptagon of willis' rather than a 'polygon of willis'. As previously mentioned, in the present study, 91.25% of total specimens were heptagonal in shape. Rest 8.75% specimens were either incomplete due to aplasia of the component arteries or a hexagon due to fused anterior cerebral arteries.

The present study has revealed that the asymmetry in the pattern of the arterial circle of willis occurs invariably always due to the absence or aplasia of component elements of the said circle or unequal length or diameter of arteries of either or both sides. In the present study 77.5% specimens have been found symmetrical, whereas, 22.5% found to have asymmetry within the component arteries.

Conclusion

In the present study 22.5% variations have been found during the course of investigation. Most common variation is seen in the posterior communicating artery. No significant variations are noted in either sex regarding shape, symmetry and completeness of the circle.

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