

Original Article

Variations in the Anatomy of the Willis' Circle: A 3-year cross-sectional study from Iran (2006-2009). Are the distributions of variations of circle of Willis different in different populations? Result of an anatomical study and review of literature

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Abstract

Background: It is not well known whether the distributions of variations of circle of Willis (CW) are different in different populations. Previous studies have indicated: (a) The variations of the structure of the CW in different populations and ethnic and (b) some correlation between those congenital anatomical variations and possible cerebrovascular diseases. The frequency of such anatomical variations has not been evaluated sufficiently in the Iranian population. The aim of this study is to find the variations of the anatomy of the vessels in the CW in sample population of Iranian people and compare it with other available studies in the literature, providing a new grouping for variations.

Methods: Samples were obtained from 200 autopsies in different ages, all retrieved in the department of Forensic Medicine, Tehran university of Medical Sciences after achieving permission from the Department of Ethics and Medico-legal Sciences. The CW was examined directly, using magnification, at the base of the brain. The cerebral vessels were observed for their configuration and their calibers were measured directly. Variations were noted and grouped into different categories.

Results: Out of the 200 specimens examined, 69 (34.5%) were compatible with the typical anatomy of the CW. In the remaining 65.5% of the specimens, there were variations in the CW. Hypoplasia of the posterior communicating arteries was the most common variation in our study. One of the autopsies showed the presence of an aneurysm (0.5%).

Conclusion: The anatomical variations found in our study were not significantly different from those reported in the literature. Based on the available data; (a) there is no evidence that the distribution of the variations of the anatomy of the CW is different in various societies and (b) the prevalence of the congenital aneurysmal changes in this region is not low in the Iranian population.

Key Words: Aneurysm, autopsy, circle of Willis, variation

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INTRODUCTION

It has been shown that about 50% of the population carries a kind of variation in their circle of Willis (CW) congenitally.^[2,3] It seems these variations, have a direct impact upon the distribution of carotid and basilar blood flow. Several studies have shown these variations play important role in development of cerebrovascular diseases.^[4-9,12-14,16,17] Enough knowledge of the cerebrovascular anatomy is necessary in microscopic surgery, especially in aneurysm surgeries. Although the relationship between the variations of CW and some vascular disease have been implemented clinically, but these variations have not been compared in various population. The aim of this cadaveric study is to report the results of a pilot and limited data gathered from the autopsy specimens performed in the Tehran Forensic Medicine center as an additive data collection from the third world to the literature of clinical neuroanatomy.

MATERIALS AND METHODS

This is a cross-sectional study, regarding the data collected from evaluating the CW directly in fresh cadaveric specimens autopsied during a 3-year period. The variants of age and sex varied in the specimens incidentally and consequently. Brains were obtained from fresh cadavers autopsied using standard techniques while all the brains having evidences of pathologies or traumatic brain injury were excluded. Finally, 200 specimens were evaluated. The vessels were observed for caliber and typical configuration and the variations were identified and grouped into seven different categories. The diameter of the vessels less than 1 mm was defined as hypoplasia. The normal vascular pattern was defined as Type A. Type B was coined as hypoplasia of the anterior communicating artery (A com hypoplasia), Type C, as A1 hypoplasia, Type D, as unilateral aplasia of the posterior communicating

artery (P com aplasia), Type E, as bilateral P com aplasia, Type F, as unilateral P com hypoplasia Type I as MCA hypoplasia, Type G bilateral P com hypoplasia, Type H other rare variations [Figure 1]. After careful irrigation and with minimal manipulation, the CW was dissected and watched carefully, in the base of the brain and using magnification with microscope. The results were analyzed using SPSS V 16.0 software, Student's *t*-test, and the Chi-square test. *P* value less than 0.05 was considered significant statistically.

Findings

The analysis of the data showed; 169 (84.5%) were male and 31 (15.5%) were female. The age range varied between 16 and 71 years (mean 41.2 (SD 14.41)). There was no significant difference between anatomic variation considering gender of the specimens ($P < 0.001$). Among these 200 cases, 69 (34.5%) had normal anatomical pattern (Type A), 28 (14%) had A com hypoplasia (Type B), 9 (4.5%) had MCA hypoplasia (Type I), 6 (3%) showed P com aplasia (Type D), and 2 cases (1%) had bilateral P com aplasia (Type G). Hypoplasia of P com was unilateral in 37 (17.5%) and bilateral in 48 cases (24%). Persistent fetal circulation defined as aplasia of the first segment of posterior communicating arteries (PCA) (Type H), was seen in one case (0.5%). In some cases there were two concomitant variations. Hypoplasia of A com and unilateral hypoplasia of P com was seen concurrently in 14 cases (7%). Concomitant bilateral P com hypoplasia and A com hypoplasia was seen in four cases (2%). Hypoplasia of the first segment of ACA and hypoplasia of P com happened together in five cases (2.5%). A com aneurysm of CW was seen in one case (0.5%) [Figure 2]. Bilateral P com hypoplasia was the most common variation detected in this study [Figure 3]. The overall comparison between our study and other autopsy series is demonstrated in Table 1.

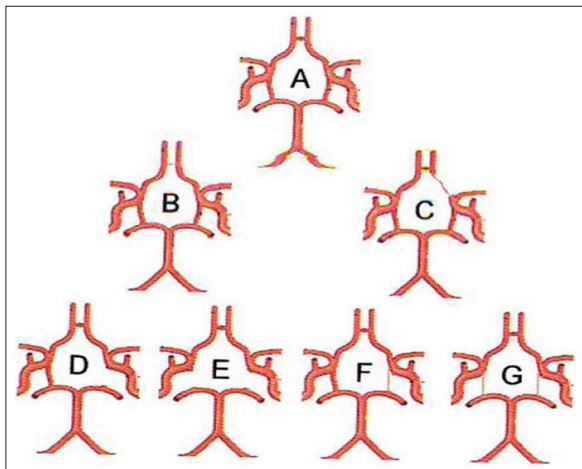


Figure 1: Variations of the findings in CW in our study



Figure 2: Anterior communicating artery aneurysm as an incidental finding (1/200 case) in our series

DISCUSSION

The purpose of this cadaveric study was to identify the congenital variations of the anatomy of CW in a rather small (200 cases) sample of population taken from fresh cadavers in the Department of Forensic Medicine to estimate the prevalence of the anatomic variations (as hypoplasia and aplasia) in each segment. This is the second study reported from the Iranian population in the literature and is the largest one after the Eftekhar *et al.*^[2] study. These results might be of interest of the researchers and neurovascular surgeons interested in the field of epidemiology of the congenital variations of brain vasculature in different races and ethnics.

There is controversy among the authors about the definition of hypoplasia. Some consider hypoplasia when diameter of a vessel is less than 1.5 mm.^[13] Others define hypoplasia when the diameter is less than 1 mm.^[3,8] This concept has been raised because it has been shown that a feeding artery of this range of diameter is unable to supply enough the terminal branches. We considered the vessel as hypoplastic when the diameter of the artery was less than 1 mm and compared it with other similar studies.

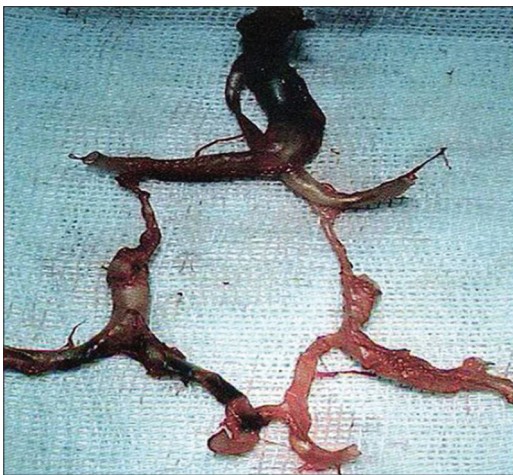


Figure 3: Bilateral post com hypoplasia (48/200 cases)

The cadavers included, were those who died of natural causes or accidents and autopsies have been done regardless the gender of the specimens. The gender of the specimens have not been mentioned in some other studies as in ours^[3,16] but some others such as the previous report from the Iranian community have shown that the variations were similar in both sexes.^[2,8] The most common variation observed in our study was bilateral hypoplasia of *P com*, happening in 24% of the cases similar to several other reports.^[4,9,10] If the CW is considered as two half-rings, the anterior part consists of carotid artery, ACA and A com of both sides and the posterior part consists of basilar artery, PCA and *P com* of both sides. According to the information obtained from autopsy studies, the anterior half-ring and the posterior half-ring were incomplete in 18.5% and 46% of the cases consequently.^[1,10,11,16] Several classifications have been described regarding the variations of the CW such as that by Lazorthes *et al.*,^[9] Macchi *et al.*,^[10] and Horikoshi *et al.*^[5] Eftekhar *et al.*^[2] tried to reclassify the data of Macchi *et al.*^[10] and compared it with Horikoshi *et al.*^[5] and found no significant difference between distributions of variations in the studies as in our study population [Table 1].

Even though the goal of our cadaveric study was not to determine the actuarial incidence of congenital aneurysm in the Iranian population, but this number (0.5%) is near to the similar studies.^[7,15] Comparing the finding of our observation with other groups, there has been no statistically significant difference between the prevalence of the variations of the CW in each segment. Those reported from the Iranian population are similar regarding the more common occurrence of aplasia of the *P com* arteries versus those reported from Moroccan and French races. It may be suggested that the congenital anatomical variation of CW is not under the influence of race and ethnics in different populations. These outputs reemphasize the demand of the literature for remarkable pooling of the related data to reach a consensus for the congenital variations in the CW in different races.

Table 1: Comparing the results of our study and similar reports in the literature. Those reported from the Iranian population are similar regarding the more common occurrence of aplasia of the *P com* arteries versus those reported from Moroccan and French races. The numbers are not sufficient for a reasonable statistical analysis of the results neither in each series nor as in the cumulated form of the data

Definition	Our study	Eftekhar ^[2]	Fisher ^[3]	EI Khamlichi ^[8]	Lazorthes ^[9]
Number of cases (<i>N</i>)	200	102	414	100	200
A com hypoplasia (%)	14	11	29	32	29.5
A1 Hypoplasia (%)	4.5	1	13	4	7.5
Unilateral <i>P com</i> aplasia (%)	3	7	-	-	-
Bilateral <i>P com</i> aplasia (%)	1	3	-	-	-
Unilateral <i>P com</i> hypoplasia (%)	17.5	27	32	25	29.5
Bilateral <i>P com</i> hypoplasia (%)	24	33	49	35	40

CONCLUSION

The findings of this article are important for those with closely related research interest. The results of evaluation of CW 200 fresh cadavers were compared with similar studies in the literature. There were no significant difference in the detected variations regarding the Iranian population and other studies except for the aplasia of the P com segments.

Based on this observation we can infer that the prevalence of variation of CW in the different studied races and ethnics are rather similar and the results have not yet been of enough amount for a valid statistical analysis. Even though these variations can be the explanatory cause of differences in neurological deficits that might be created by same surgical vascular techniques used for different patients, but commutation of data are needed to be performed by different researchers in any community to fill up the defect in the literature.

Limitations and suggestions

The accuracy of the anatomical studies evaluating the intracranial vasculature is highly dependent on the technical preparation of the specimens. Given the high prevalence of variation of CW (% 65/5),^[2,3] it is essential to investigate full details of the anatomy of brain vascular in any surgical intervention around the CW, especially in vascular lesions in this region. It is recommended to evaluate these variations whenever temporary or permanent vascular occlusion is necessary in each segment of the CW.

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