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Assessment of the Prevalence of Vascular Anomalies of the Circle of Willis Based on the Autopsy of Cadavers in Kurdish Race Between 2016 and 2017

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ABSTRACT

Introduction: Cerebral arterial variations are commonly associated with cerebrovascular disease and should be considered during brain surgeries. Since some cerebrovascular diseases are seen in certain breeds, it seems that different distributions of cerebral arterial variations depend on race. **Aim**: The aim of this study was to determine the random incidence of vascular anomalies of the circle of Willis in autopsy of the cadavers. **Material and Methods**: In this study, 107 autopsy cadavers were examined. The brain was removed from the skull through standard autopsy procedures and with great care, the circles of Willis were evaluated, their main branches were accurately dissected, their anatomy was examined using a glass plate and variations were recorded. **Results**: The mean age of the cadavers was 57.77 years, and 72.9% of them were male. The forms of circle of Willis of the cadavers were categorized according to the Lazort classification, from which 48.6% had form 1,39.3% form 4, and 12.1% form 6. Out of all patients, 51.4% had hypoplasia and 67.3% had asymmetry. There was a significant relationship between asymmetric incidence and the age of cadavers, the incidence of hypoplasia and sex of the cadavers, and the forms of the circle of Willis and the diameter of segment ($p<0.05$). **Conclusion**: Due to the high incidence of asymmetry (67.3%) and hypoplasia (51.5%), it seems necessary to perform a complete review of the details of cerebrovascular anatomy in any surgical intervention around the circle of Willis, especially in vascular lesions of this area.

Keywords: Circle of Willis, cadaver, autopsy.

1. INTRODUCTION

The shape of the cerebral vascular system was first defined by Thomas Willis in 1658, who was able to draw a picture of this anastomosis (1, 2). Although some cases of incomplete *circle* of Willis were mentioned in the early studies, the study of the *circle* of Willis variations began in the twentieth century (3). The *circle* of Willis is located at the base of brain and includes two sides of internal carotid with connection to vertebrobasilar artery anastomosis. Of course, there may also be variations in the classic look of the *circle* of Willis. The diameter of the vessels may be different; sometimes they are hypoplastic vessels. Sometimes these vessels are two, or sometimes absent in general. Various studies have shown that these variations are seen in 20-50% of normal people. If anatomical variations are asymmetric, aneurysm usually grows on arteries with greater diameter (due to the higher turbulence), and variation in the *circle* of Willis is seen in more than 90% of the saccular aneurysms, and even the accompanying migraine is mentioned (4). Any change in the normal anatomy of the *circle* of Willis causes and exacerbates the symptoms of vascular diseases such as infarction aneurysm and other vascular anomalies (5). Cerebral arterial variations (the arterial *circle* of Willis) are commonly associated with cerebrovascular disease and should be considered during brain surgeries (6, 7). Considering that some cerebrovascular diseases are seen in certain races, different distributions of cerebral arterial variations seem to depend on race (8-12). Although cerebral arterial variations have been reported in other parts of the world, they have been reported to be extremely rare in Iran, and no study has been done to investigate

the variations of the *circle* of Willis in Kermanshah, one of the metropolitan cities of Iran.

2. AIM

The aim of this study was to determine the prevalence of cerebrovascular variations of the circle of Willis based on the autopsy cadavers in Kermanshah province (Kurdish race).

3. PATIENTS AND METHODS

This study was approved by the Ethics Committee of Kermanshah University of Medical Sciences, Kermanshah, Iran. In a cross-sectional study, 107 autopsy cadavers of different ages and sexes at the forensic center were included between 2016 and 2017. The close relatives of the cadavers were satisfied to perform autopsies. Among the autopsy cadavers, the brains with pathology or evidence of injury following head trauma were excluded. The brain was removed from the skull through standard autopsy methods and with great care, and the *circle* of Willis was evaluated by the assistant designer. The *circle* of Willis and its main branches were carefully inscribed, and their anatomy was examined. The variations were recorded and photographed as needed. The circle of Willis was classified into different groups in terms of the diameter of its segments and the existence of variations: a) normal anatomic pattern, b) hypoplasia of anterior communicating artery, c) hypoplasia of anterior cerebral artery, d) one-sided aplasia of the posterior communicating artery, e) bilateral aplasia of the posterior communicating artery, f) bilateral hypoplasia of the posterior communicating artery and g) other variations. In order to investigate the circle of Willis: a) the skull of the corpses was unlocked with the help of a special saw, b) the cranial nerve in the skull and then the carotid were cut, c) the brain stem was released and the whole brain was removed completely, d) the small branches isolated from the original field were cut, and e) the circle of Willis was completely removed and measured by a glass plate and subtle line. By this method, the whole circle of Willis, including the anterior cerebral area, the posterior cerebral area, middle cerebral area, anterior communicating area, posterior communicating area, vertebrobasilar artery, basilar artery and internal carotid artery was measured. To obtain the diameter of the vessels, the resulting number was multiplied by 2, and was based on the number π. By definition, asymmetry refers to cases in which the diameter of the arteries of the same name is at least one mm apart, and hypoplasia refers to the arteries of less than 1 mm (13). Hypoplasia was divided according to the *Lazort classification (14).*

Statistical analysis

SPSS version 21 software was used for data entry and analysis. To summarize the results, descriptive statistics (mean, standard deviation, frequency and percentage) were used. To compare qualitative and quantitative data were used Chi-square test and Student's t-test, respectively. The significance level was set at <0.05.

4. RESULTS

The age of the subjects was between 16 and 83 years, with mean and standard deviation of 57.77 ± 14.49 years. The highest prevalent age ranges in the cadavers were 60-70 (29.9%) and 50-60 years (25.5%) (Table 1). Out of 107 cadavers, 78 (72.9%) were male, 55 (51.4%) had hypoplasia, and 72 (67.3%) had asymmetry. The circle of Willis forms in the cadavers included 48.6% type 1, 39.3% type 4 and 12.1% type 6. Out of 55 cadavers with hypoplasia, hypoplasia was located in left posterior communicating artery in 76.3% and left and right posterior communicating arteries in 23.7%. Out of 72 cadavers with asymmetry, asymmetry was located in carotid arteries on both sides in 51.4% and vertebral *artery in* 48.6% of samples. *The lowest mean* diameters of segments (mean diameter of arteries of the circle of Willis) in the cadavers were 5.6 mm (30.8%) and 4-5 mm (23.4%), with a total mean diameter of 5.25 mm in all the cadavers.

Variable	N(%)
Age group, year	
≤40	16 (15)
40-50	12 (11.2)
50-60	27 (25.5)
60-70	32 (29.9)
70-80	18 (16.8)
>80	2 (1.9)
Sex	
Male	78 (72.9)
Female	29 (27.1)
The circle of Willis forms	
1	52 (48.6)
4	42 (39.3)
6	13 (12.1)
Hypoplasia	
Yes	55 (51.4)
No	52 (48.6)
Location of hypoplasia (n=55)	
Only left posterior communicating artery	42 (76.3)
Left and right posterior communicating arteries	13 (23.7)
Asymmetry	
Yes	72 (67.3)
No	35 (32.7)
Location of asymmetry(n=72)	
Carotid arteries on both sides	37 (51.4)
Vertebral artery	35 (48.6)
Mean diameter of segment, mm	
≤3	8 (7.5)
3-4	12 (11.2)
4-5	25 (23.4)
5-6	33 (30.8)
6-7	22 (20.6)
>7	7 (6.5)

Table 1. Baseline characteristics of the autopsy cadavers (n=107)

Variables	The circle of Willis forms			P-value
	1	4	6	
Age, year Mean ± SD	56.38 ± 15.19	59.95 ± 13.08	56.30 ± 16.18	0.645
Sex				
Male	37 (71.2)	31 (73.8)	10 (76.9)	0.903
Female	15 (28.8)	11 (26.2)	3 (23.1)	
Mean diameter of segment, mm Mean ± SD	4.73 ± 1.17	4.97 ± 1.47	5.75 ± 1.25	0.009

Table 2. Correlation between the circle of Willis forms and some variables

Table 2 shows the correlation between the circle of Willis forms and three variables of age, sex and diameter of segment. There was only a significant correlation between the

diameter of segment and the circle of Willis forms; diameter of segment was higher in from 6 than form 4, and higher in from 4 more than form 1 (p=0.009).

Table 3 shows the correlation between hypoplasia and three variables of age, sex and diameter of segment. There was merely a significant correlation between sex and hypoplasia; most cadavers with hypoplasia were female, but most cadavers without hypoplasia were male (p=0.031).

Variables	Hypoplasia		P-value
	Yes	No	
Age, year Mean ± SD	60.10 ± 13.01	55.30 ± 15.66	0.086
Sex Male Female	35 (63.6) 20 (36.4)	43 (82.7) 9 (17.3)	0.031
Mean diameter of segment, mm Mean ± SD	5.21 ± 1.52	5.29 ± 1.29	0.734

Table 3. Correlation between hypoplasia and some variables

Table 4 shows the correlation between asymmetry and three variables of age, sex and diameter of segment. There was only a significant correlation between age and asymmetry; the mean age was higher in the cadavers with asymmetry than the cadavers without asymmetry (p=0.032).

Variables	Asymmetry		P-value
	Yes	No	
Age, year Mean ± SD	62.34 ± 10.51	55.55 ± 15.66	0.032
Sex Male Female	56 (77.8) 16 (22.2)	22 (62.9) 13 (37.1)	0.112
Mean diameter of segment, mm Mean ± SD	5.51 ± 1.47	5.12 ± 1.36	0.175

Table 4. Correlation between asymmetry and some variables

5. DISCUSSION

In this study, the mean age of the autopsy cadavers was 57.77 years; whereas, those of other studies were 41.2 years (15), 39 years (14) and 37 years (16). In this study, 72.9% of cadavers were male; whereas, 84.5% (15), 81% (14) and 80% (16) of cadavers were male in other studies. Based on the results of the present study, the circle of Willis forms of the cadavers were based on the classical Lazort calcification (48.6% form 1, 39.3% form 4 and 12.1% form 6). However, in another study (14), 50% were type I, 38% were type 4 and 6% were type 6. The results of the present study indicated that 67.3% of autopsy cadavers had asymmetry variation. In the studies of Ramakhashemi and Mahmodi (15), Zulu et al. (16), De Silva et al. (13), Iqbal et al. (17) and Singh et al. (18), asymmetry variations were reported in 65.5%, 10%, 56.4%, and 52%of autopsy cadavers, respectively.

In the present study, 51.4% of autopsy cadavers had hypoplasia. In the studies of Zulu et al. (16), De Silva et al. (13), Iqbal et al. (17) and Singh et al. (18), 33.2%, 86%, 24%, 18.6% of cadavers had hypoplasia, respectively. Based on the results of this study, hypoplasia was 66.7% in the left and 33.3% in the right posterior communicating arteries. Ramakhashemi and Mahmodi (15) found 17.5% posterior communicating artery hypoplasia in one side and 24% in two sides. In a study by Zulu et al. (16), the most common sites of hyperplasia were found in the left posterior communicating artery (54.5%) and right posterior communicating artery (45.5%). In a study by De Silva et al. (13), posterior communicating artery hyperplasia was observed in 70% of cadavers, and anterior circulation was identified in 30% of cadavers. In the study of Ramakhashemi and Mahmodi (15), anterior communicating artery hyperplasia and anterior cerebral artery hypoplasia were seen in 14% and 4.5% of cadavers, respectively.

According to the results, the mean diameter of arteries of the circle of Willis was 5.25 mm in the cadavers. As for the correlation between asymmetry, the circle of Willis forms and hypoplasia, there were just correlations between the asymmetric incidence and the age of the cadavers, the circle of Willis forms and the diameter of segment, and hypoplasia incidence and sex. In the study of Karamoziyan et al. (14), there was no significant relationship between the asymmetry incidence and the diameter of segment. In the study of Zulu et al. (16), in line with the results of the present study, there was a correlation between the age of cadavers and the incidence of hypoplasia.

The difference in mean age, male frequency, frequency of variance in the anatomical pattern of the circle of Willis and the incidence of hypoplasia and asymmetry in the autopsy cadavers in different studies can be due to differences in the geographical areas of the subjects, the difference between definition of hypoplasia and asymmetry, or vascular measurement tools. There were two limitations in the present study. First, there is a possible change that can be seen in vascular diameter in the afterlife, which can affect the measurements. Second, this study was a cross-sectional study, so the relationships achieved cannot be called cause and effect.

6. CONCLUSIONS

Based on the results of this study, due to the high incidence of asymmetry (67.3%) and hypoplasia (51.5%), a complete review of the details of cerebrovascular anatomy in any surgical intervention around the circle of Willis, especially in vascular lesions of this area seems to be necessary. The existence of variation scan indicate the difference in neurological defects caused by vascular events in different individuals. It is also suggested that future studies determine the prevalence of vascular anomalies of the circle of Willis in the cadavers of different races.

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