



Journal of Medical Sciences

ISSN 1682-4474

science
alert

ANSI*net*
an open access publisher
<http://ansinet.com>

JMS (ISSN 1682-4474) is an International, peer-reviewed scientific journal that publishes original article in experimental & clinical medicine and related disciplines such as molecular biology, biochemistry, genetics, biophysics, bio-and medical technology. JMS is issued eight times per year on paper and in electronic format.

For further information about this article or if you need reprints, please contact:

Ahmad Ali Ghanbari
Department of Anatomy,
Faculty of Medicine,
Tabriz University of Medical
Sciences,
Tabriz, Iran

Tel: +8-411-3364672/3854348
Fax: +98-411-3342086

A Study of Arterial Variation of Willis Circle in 100 Human Brain in East Azarbaijan, Iran

¹Ahmad Ali Ghanbari, ²Bahram Samadi Rad,
³Feraidoun Ashrafian and ⁴Hamid Tayefi Nasrabadi

The aim of this study was to evaluate the variation of Willis circles and the arterial branches which participate to make them in 100 male cadavers in East Azarbaijan-Iran. The Willis arterial circle of 100 East Azarbaijanian, Iran male cadavers have been exposed, the diameters of the arteries which participate to make the circles, have been measured by caliper and finally photographed and studied by using t-test. In 49% of subjects there have been complete circle of Willis. The posterior communicating arteries (PcomA) of these circles been symmetrical and had 1.5 mm diameter. The difference in comparison with those indicated in Gray's anatomy, was not significant ($p>0.05$). Twenty eight percent of subjects showed complete circle and symmetrical PcomA but the diameter of posterior communicating arteries were less than 1 mm (considered hypo functional as collateral routes). The difference of this category in comparison with reference been significant ($p<0.05$). Twelve percent of cadavers showed right or left side hypo plastic PcomA ($p<0.05$) and 11% showed incomplete circle with absence of right or left PcomA ($p<0.05$). The difference of these last two groups also been significant. In all of this studied subjects, the anterior communicating artery been existed. The diameter of the arteries, were about 1.5 mm.

Key words: Willis arterial circle, variations of Willis circle, posterior communicating arteries, anterior communicating arteries

¹Department of Anatomy, Faculty of Medicine,
Tabriz University of Medical Sciences, Tabriz, Iran

²The Forensic Center of East Azerbaijan, Tabriz University of Medical Sciences,
Iran

³The Forensic Center of East Azerbaijan, Iran

⁴Tabriz University of Medical Sciences, Iran

INTRODUCTION

The arterial circle of Willis is formed by anastomosing between the branches of internal carotid arteries and the basilar artery. It is located in the interpeduncular cistern at the base of the skull (Warwick, 1995). The circle of Willis or *circulus arteriosus*, has a great importance as the main brain collateral circulation specially in the old people who may have reduced brain blood supply due to senile arteriosclerosis. In normal condition, this circle is formed anteriorly by two anterior cerebral arteries, anterior branches of right and left internal carotid arteries, which in turn are joined by the anterior communicating artery. Posteriorly on each side, each internal carotid artery by its posterior branch, the posterior communicating artery, communicate with posterior cerebral artery, branches of basilar artery. The circle of Willis and the arterial branches which participate to make it show many variations in calibers and some of them may be hypoplastic or absent. About 60% of circles show varieties of anomalies and hence the completed described circle may involve minority of cases (Standring, 2005). In about 90% of complete circles, some branches may be sufficiently narrowed in caliber to cast doubt on their functional values as a collateral route. The anterior communicating artery may frequently be double or even triple while the posterior communicating arteries seem to be more hypoplastic (Warwick, 1995; Standring, 2005). As studied, there is no published data from Iran in the above mentioned topic and therefore this study aimed to evaluating the variations of Willis circle and its involved arteries, in East Azerbaijan, Iran.

MATERIALS AND METHODS

At East Azerbaijan legal medicine center, during six months (from May 2008 to October 2008), the brain of 123 deceased male subjects that were candidate for autopsy, been taken out of the skulls and for the first stage of study, the fresh brains (Fig. 1), the basilar vessels and the Willis arterial circle were examined carefully and the diameters of the arteries which participate to make the circles, have been measured by caliper and finally photographed by a Nikon digital camera. For further examination and photography, the brains were fixed by embedding in 10% formaldehyde solution for two weeks. After fixation which let the brains to become firmer and the vessels to be darker than fresh ones, they were examined again. In re examination, 23 of brains which showed some kind of damages in the basilar vessels and the circles during autopsies, were excluded. The rest 100 brains which had no remarkable damages in Willis circles



Fig. 1: Some brains which been used for studying of Willis circle variations



Fig. 2: Some of the most variations of Willis circle which found in this study

were examined precisely, they diameters were measured by caliper and photographed by Praktica BC1 camera with macro lens and Kodak 135 mm color films (Fig. 2).

The main questions of the study were:

- How many arterial circle of Willis were completed and the posterior communicating arteries were symmetrical in size
- In how many brains the posterior communicating arteries showed variation in size symmetric or asymmetric

- In how many brains the posterior communicating arteries were symmetric or asymmetric. Undeveloped and vestigial
- In how many brains the anterior communicating artery was complete and well developed or showed any variations

The findings were classified in two tables and the final data were analyzed by using t-test and compared with the similar frequency of variations in reference textbooks of human anatomy.

In all 100 studied brains, the anterior communicating artery with about 1.5 mm in diameter been existed.

RESULTS AND DISCUSSION

The results of this study on East Azerbaijani male cadavers (whose parents and grandfathers and mothers also born and lived in East Azerbaijan of Iran) with the average 55 years old, been shown in Table 1. With the combination of rows 3 and 4 as the name of complete circle with right or left hypo plastic posterior communicating arteries and also the 5 and 6 rows as the name of incomplete circle with absence of right or left posterior communicating arteries. Finally four groups of variations in Willis arterial circle been studied (Table 2).

Table 1: The anatomical patterns of Willis arterial circle in 100 male east Azarbaijani individuals

Types	The anatomical pattern of Willis circle	No.
1	Complete circle with symmetrical 1.5 mm diameter of post. communicating arteries	49
2	Complete circle with symmetrical 1 mm diameter of post. communicating arteries	28
3	Complete circle with left side hypo plastic post. communicating artery	5
4	Complete circle with right side hypo plastic post. communicating artery	7
5	Incomplete circle with absence of left side post. communicating artery	6
6	Incomplete circle with absence of right side post. communicating artery	5
Total		100

Table 2: The anatomical patterns of Willis arterial circle in 100 male east Azarbaijani individuals

Types	The anatomical pattern of Willis circle	No.
1	Complete circle with symmetrical 1.5 mm diameter of post. communicating arteries	49
2	Complete circle with symmetrical 1 mm diameter of post. communicating arteries	28
3	Complete circle with left or right side hypo plastic post. communicating artery	12
4	Incomplete circle with absence of left or right side post. communicating artery	11
Total		100

In this study, as it is shown in Table 2, 49% of cadavers had complete arterial circle with symmetric posterior communicating arteries having 1.5 mm diameter. The difference, in comparison with those reported in text books of anatomy was not significant ($p>0.05$). Twenty eight percent showed complete circle with symmetric posterior communicating arteries having less than 1 mm diameter, which could be considered as hypo dynamic arteries in function. The difference of this category with those in text books of anatomy was significant ($p<0.05$). The difference in 12% of Willis circles which had right or left hypo plastic posterior communicating arteries was significant ($p<0.05$) and finally the last group in the current study that include 11% of circles with absence of right or left posterior communicating arteries had a significant difference ($p<0.05$). According to this study, 77% of male cadavers, the arterial circle of Willis were complete. Although in 28% of them the posterior communicating arteries had less than 1 mm diameter, but they could be considered as efficient collateral routes in long term reduced brain blood circulation. A study at Dutch Utrecht University (Hartkamp and Van der Grond, 2000) showed that some arteries of Willis circle are larger genetically due to its homodynamic causes which show the adaptation between their calibers and need of brain circulation. For example, the posterior communicating arteries according to how much the internal carotid arteries will take part in brain circulation may have increased or diminished in diameters. These variations in calibers may be congenital or may occur during childhood or adulthood life. In another study at vascular surgery department of Amsterdam Medical Center (Hoksbergen, 2000), angiographic research showed that in 95% of people the anterior communicating artery has the sufficient caliber to supply the blood of the other side cerebral hemisphere. In 4% it may be hypo functional and in 1% may have no function. The posterior communicating arteries in 48% of individuals been adequately functional and in 38% cases showed varieties of hypo function and in 7% been vestigial and embryonic in shape and size with no haemodynamic efficiencies. In a metaanalysis at Virtual hospital of Iowa (Bregman *et al.*, 2008), 83 variations were demonstrated in arteries participating in Willis arterial circle in which the most of abnormalities were in posterior communicating or posterior cerebral arteries. In another series (Tanaka *et al.*, 2006), it was showed that 105 of 118 subjects had the textbook type complete Willis circles, 6 showed hypoplasia of anterior cerebral arteries and 7 subjects with hypoplasia of posterior cerebral arteries. In a study of Papantchev *et al.* (2007) examining the Willis circles of 112 cadavers, the variations such as hypoplasia or lack of a

branch on the left side of Willis circle was identified and it was suggested that in cannulation of the brachiocephalic artery and selective perfusion of right cerebral hemisphere of patients, these variations and the probable stroke of left cerebral hemisphere must be kept in mind. In another study of Waaijer *et al.* (2007) in order to assess the presence of the anterior and posterior collateral pathways in patients with symptomatic carotid artery stenosis, multislices CT angiography was performed in 91 patients and 91 control subjects. This study showed that in Willis circles which had been made by the arterial branches with more than 1 mm diameters, the anterior and posterior communicating arteries were present, but in those with lower than 1 mm, the incidence of hypoplasia of the anterior communicating arteries been more than the posterior ones. Krabbe-Hartkamp *et al.* (1998) by angiographic studying on 150 patients showed that only 42% of patients had the entirely complete Willis circles. Eftekhar *et al.* (2006) at Sina hospital of Tehran University of Medical Sciences, studied the variations of Willis circle in 102 brains of recently deceased Iranian males. The results indicated that the variations of Willis circle of studied subjects were not significantly different to those of more diverse populations reported in the literature but, in 3% of Willis circles, the right and left posterior communicating arteries were absent.

CONCLUSION

The current study indicates that the incidence of hypodynamic posterior communicating arteries and absence of these arteries on right or left side, been less than the data of Standring *et al.*, reported in gray's anatomy. It also indicates that the East Azerbaijani male individuals to have some more effective Willis arterial circles.

If the next studies can show the low incidence of CVA in the similar group of people, it will be a good reason to accept the results of our study.

REFERENCES

Bregman, R.A., A.K. Afifi and R. Miyauchi, 2008. Eighty three variations in circle of willis. Illustrated Encyclopedia of Human Anatomic Variation: Opus II: Cardiovascular System. http://www.anatomyatlases.org/AnatomicVariants/Cardiovascular/Image_s0200/0294D.shtml.

- Eftekhar, B., M. Dadmehr, S. Ansari, M. Ghodsi, B. Nazparvar and E. Ketabchi, 2006. Are the distributions of variations of circle of Willis different in different populations? Results of an anatomical study and review of literature. *BMC Neurol.*, 6: 22-22.
- Hartkamp, M.J. and J. Van-der-Grond, 2000. Investigation of the circle of Willis using MR angiography. *Medica Mundi*, 44: 20-27.
- Hoksbergen, A.W.J., 2000. Collateral variation in circle of Willis. *Am. J. Stroke*, 31: 1656-1660.
- Krabbe-Hartkamp, M.J., J. Van-de-Grond, F.E. De-Leeuw, J.C. De-Groot and A. Algra *et al.*, 1998. Circle of Willis: Morphologic variation on three-dimensional time-of-flight MR angiograms. *Radiology*, 207: 103-311.
- Papantchev, V., S. Hristov, D. Todorova, E. Naydenov and A. Paloff *et al.*, 2007. Some variations of the circle of Willis, important for cerebral protection in aortic surgery-a study in Eastern Europeans. *Eur. J. Cardiothorac Surg.*, 31: 982-989.
- Standring, S.G., 2005. *The Anatomical Basis of Clinical Practice, Vascular Supply of the Brain*. 39th Edn., Churchill Livingstone, Philadelphia, ISBN:0-443-06676-0, pp: 301-302.
- Tanaka, H., N. Fujita, T. Enoki, K. Matsumoto, Y. Watanabe, K. Murase and H. Nakamura, 2006. Relationship between variations in the circle of Willis and flow rates in internal carotid and basilar arteries determined by means of magnetic resonance imaging with semiautomated lumen segmentation: Reference data from 125 healthy volunteers. *AJNR Am. J. Neuroradiol.*, 27: 1770-1775.
- Waaijer, A., M.S. Van-Leeuwen, H.B. Van-der-Worp, H.J. Verhagen, W.P. Mali and B.K. Velthuis, 2007. Anatomic variations in the circle of Willis in patients with symptomatic carotid artery stenosis assessed with multidetector row CT angiography. *Cerebrovasc Dis.*, 23: 267-274.
- Warwick, W.G., 1995. *The Anatomical Basis of Medicine and Surgery*. 38th Edn., Churchill Livingstone, Philadelphia, ISBN: 0-443-05717-6.