

Comparative study of the arterial circle of Willis in individuals with or without cerebrovascular disorders

Abstract

The study is devoted to describe the anatomy of Willis circle in people with and without the cerebrovascular pathology. It was investigated in 243 angiograms of both males and females between the ages of 18 and 72. 120 patients had no signs of cerebrovascular pathology, and 123 patients had various types of disorders of the cerebral circulation.

Results of the study have shown that only 32% of patients from the group without cerebrovascular disorders have the classical type of Willis circle. In 68% of patients, the atypical Willis circle was found, namely: 23% – hypoplasia of the anterior communicating artery, 21% – aplasia or hypoplasia of one of the posterior communicating arteries, 17% – combination of both anterior and one of the posterior communicating arteries aplasia, 4% – anterior and both posterior communicating arteries aplasia, 3% – parietal contact of both anterior cerebral arteries.

Patients with cerebrovascular pathology show the typical anatomy of the Willis circle only in 2%. Other ones have different type of variation: aplasia of one of the posterior communicating artery have been noted in 53%, aplasia of both posterior communicating arteries – in 26%, combined aplasia of both anterior and posterior communicating arteries have been met in 19% of cases. Based on the above, it can be assumed the atypical type of the Willis circle is a predisposing factor for the development of cerebrovascular disorders.

Keywords: Circle of Willis, anterior communicating artery, posterior communicating artery, anterior cerebral artery, brain

Volume 10 Issue 1 - 2023

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Received: March 23, 2023 | **Published:** April 19, 2023

Introduction

The brain is supplied with the blood from two sources: the internal carotid artery and the vertebrobasilar systems. There are anastomoses between these two vascular systems at the base of the brain, called Willis circle. Circle of Willis is a compensatory mechanism in disorders of hemodynamics. Its purpose is to make a collateral circulation of brain if there is a violation of blood flow in any segment of arteries supplying the brain. The proximal portion of the anterior cerebral arteries, the anterior communicating artery that connects both right and left anterior cerebral arteries near the frontal poles of the cerebral hemispheres, the sphenoidal segment of the internal carotid artery, the posterior communicating artery, and the proximal portions of the posterior cerebral arteries are involved in the formation of the Willis circle.¹

However, the full circle of Willis can only be seen in 24-50% of people.²⁻⁵ The anatomy of the Willis circle is of clinical significance, since atypical structure of it is associated with an increased risk of cerebrovascular diseases. Studies of patients show that incomplete variants of Willis circle are associated with stroke,^{6,7} aneurysms,^{8,9} etc. The most dangerous anomaly is anterior or posterior trifurcations of the internal carotid artery, which affect the distribution of blood in the brain and are permissible until occlusive changes occur that require good collateral circulation. With anterior trifurcation, the internal carotid artery delivers 50% of blood to the brain, while the opposite artery – 30% of blood only, because of hypoplasia of the proximal segment of the anterior cerebral artery. The internal carotid artery on the side of its posterior trifurcation delivers about 50% of blood to the brain, the opposite internal carotid artery – 40% of blood, and the basilar artery – 10% of blood only.^{10,11}

Many studies that describe the structure of the arterial vessels of the brain are aimed at studying the anatomy of the Willis circle in people with cerebrovascular pathology.¹² There is a deficiency of information about the variations in the structure of the arterial bed of the brain in people without cerebrovascular disorders. The aim of present study is to compare the variability of Willis circle in people with pathology of the cerebral circulation and those without it.

Material and methods

The study was carried out in 1134 Military Clinical Medical Center of the Republic of Belarus. We investigated 243 angiograms of both males and females between the ages of 18 and 72 with the help of the method of TOF-angiography (time-of-flight, non-contact, tomograph Neusoft Medical Systems 0.35T). Of these, 120 patients were without signs of cerebrovascular pathology, and 123 patients had various types of disorders of the cerebral circulation: 20.5% with acute cerebral circulatory disorders, 45.5% had consequences of cerebral strokes, 26% with transient ischemic attacks, and 8% with the chronic dyscirculatory encephalopathy. Statistical processing of the data was carried out using the program “Statistica 12.5”.

Results and discussion

When studying 120 MR-angiograms of individuals without disorders of cerebral circulation we have found the typical anatomy of Willis circle in 32% of cases only (Figure 1). In other 68% of patients from this group, the different variations were found, namely: hypoplasia/aplasia of the anterior communicating artery was noted in 23% (Figure 2), aplasia or hypoplasia of one of the posterior communicating artery in 21% of cases, 17% of patients showed the combination of both anterior and one of the posterior communicating

arteries, aplasia of the anterior and both posterior communicating arteries were noted in 4% of cases, the parietal contact of both anterior cerebral arteries were found in 3%.

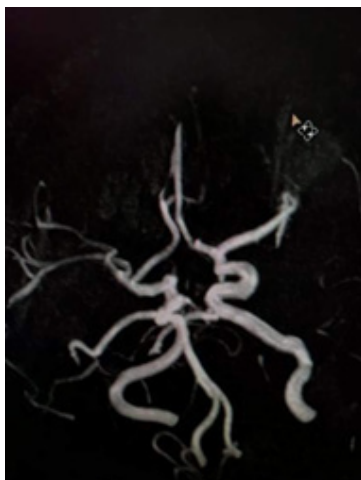


Figure 1 Typical circle of Willis.

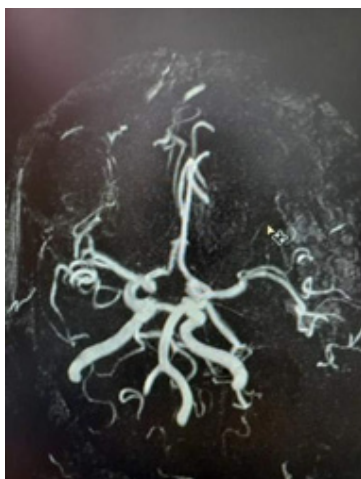


Figure 2 Hypoplasia/aplasia of the anterior communicating artery.

Deviations in the development of structures of Willis circle arise, as a rule, during fetal development, which may be caused by abuse by pregnant women with smoking; use the alcohol or drugs; overdose of sedative pills; unauthorized use of drugs not prescribed by a physician. The deep stress, viral infection and many other factors can affect the pregnancy.¹³

The study of the anatomy of the arterial circle of Willis in patients without cerebrovascular pathology showed the following results: the typical (classical) structure of Willis circle was noted in 38% of cases; 19% of patients showed the posterior trifurcation of the internal carotid artery; aplasia of the posterior communicating artery was found in 17.5% of cases; the multiple atypical Willis circle in which the several variations of the vessels of the anterior or posterior parts of the same circle was described in 14% of cases. In addition, in 11.5% of cases, the “rare variants” were detected, which, as a rule, occur in the anterior part of the Willis circle. The same variations were described by other authors.^{13,14}

The typical anatomy of Willis circle in patients with cerebrovascular pathology was revealed in 2% of cases only. Usually they had different atypical variability of the circle. Aplasia of one of the posterior communicating artery was noted in 53% of cases; aplasia

of both posterior communicating arteries in 26%, the combined aplasia of both anterior and posterior communicating arteries was found in 19% of cases. Our results were confirmed in the studies of other authors.^{4,10,13,15,16} In fairness, it should be noted that various types of aplasia and hypoplasia may not manifest themselves independently, the pathology was detected as a random diagnostic finding during MRI.^{1,2,8}

Conclusion

The typical structure of the arterial circle of Willis is the most optimal for providing collateral blood flow and (it was found in 32% of patients without cerebrovascular pathology and only in 2% of persons with disorders of cerebral circulation). Various types of anomalies of development of the Willis circle are a predisposing factor for the development of pathologies of the blood supply to the brain.

Acknowledgments

None.

Conflicts of Interest

None.

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