

A short overview of anatomical variations of the circle of Willis in adult human brains

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Abstract

The circle of Willis constitutes a key collateral network for preserving a satisfactory cerebral perfusion. Therefore, changes in the normal morphology of the circle of Willis may lead to different types and degrees of cerebrovascular disorders including aneurysms, infarctions and other vascular abnormalities.

This short report summarizes the main types of anatomical variations of the circle of Willis such as: (i) hypoplasia (affecting the posterior communicating artery; the circular part of the posterior cerebral artery; the circular part of the anterior cerebral artery; or the anterior communicating artery); (ii) accessory vessels (in the form of duplications/triplications of one of the components of the polygon); (iii) anomalous origin (consisting of the persistence of the embryonic derivation of the posterior cerebral artery from the internal carotid); (iv) absent vessels (of one or other posterior communicating arteries).

Besides single anomalies, multiple abnormalities (consisting of different combinations of the variations mentioned above) of the circle of Willis are not rare.

In addition to different vascular accidents, it is important to identify the status of the circle of Willis in order to determine the capability of the brain circulation in operations, especially for cerebral aneurysms.

Similar to other countries in the world, it is important to assess the magnitude and different types of anatomical variations in adult human brains in the Albanian population.

Keywords: aneurysms, cerebrovascular disorders, circle of Willis, hypoplasia.

Circle of Willis

The circle of Willis consists of a symmetrical arterial circle, with a single anterior communicating artery and bilateral posterior communicating arteries, which usually have smaller diameters than the pre-communicating segments of the posterior cerebral artery on the corresponding side (1-3).

Furthermore, the circle of Willis constitutes a key collateral network for preserving a satisfactory cerebral perfusion (4). Therefore, changes in the normal morphology of the circle of Willis may lead to different types and degrees of cerebrovascular disorders including aneurysms, infarctions and other vascular abnormalities (2,4). It has been suggested that the anatomical variations of the circle of Willis may be genetically determined – occurring in an early embryonic stage and carried on in later life (4,5).

It has been recently argued that the condition of the circle of Willis is seminal for the capability of the brain circulation in operations for cerebral aneurysms, but also in ligation of the internal carotid artery (4). From this perspective, a comprehensive knowledge of the anatomical variations of the circle of Willis is particularly valuable to surgeons for a careful and scientific planning of their operations, especially in the case of complex patients (4).

Anatomical variations of the circle of Willis

There are several variations of the normal pattern of the circle of Willis, such as those in which certain segments are hypoplastic, absent, or duplicated (3). Briefly, the main types of anatomical variations of the circle of Willis are as follows (4):

- Hypoplasia (affecting the posterior communicating artery; the circular part of the posterior cerebral artery; the circular part of the anterior cerebral artery; or the anterior communicating artery);
- Accessory vessels (in the form of duplications/triplications of one of the components of the polygon);
- Anomalous origin (consisting of the

persistence of the embryonic derivation of the posterior cerebral artery from the internal carotid);

- Absent vessels (of one or other posterior communicating arteries).

Besides single anomalies, multiple abnormalities (consisting of different combinations of the variations mentioned above) of the circle of Willis are not rare. Hence, a fairly recent study reported a prevalence of multiple anomalies of 28% (14 out of 50 circles included in this study) (4). Among the multiple variations reported in this study, 10 circles (20%) had two anomalies, whereas further four circles (8%) had more than two anomalies (4).

Magnetic resonance angiography

Magnetic resonance angiography presents the functional morphology of the arterial circle (3,6-9). In addition, magnetic resonance angiography offers a means for hemodynamic assessment of blood flow and direction through different quantitative phase contrast techniques which have been exhaustively described in the international literature (3,10-12).

The conventional contrast angiography involves many risks such as atheroembolic or thromboembolic accidents following the intra-arterial catheter procedures, puncture site hematoma development, or adverse reactions to contrast medium (3,13).

Besides the absence of the aforementioned risks, magnetic resonance angiography reduces also the costs of cerebral angiography by preventing admission to hospital for post angiographic observation, a condition which is required in the case of conventional cerebral angiography (3). Therefore, due to its non-invasive character, magnetic resonance angiography has enabled in vivo investigation of the circle of Willis in normal individuals, as well as in patients (3).

As for the different techniques of this procedure, the intracranial magnetic resonance angiography has been indicated as a very accurate method for revealing the arterial circle morphology and assessment of its diameters (3,14). Furthermore,

it has been demonstrated that magnetic resonance angiography can correctly determine both the blood flow direction and its amount (3,15).

Studies in Albania

There are no reports on the distribution of the anomalies of the circle of Willis in the adult population of Albania, a former communist country in the Western Balkans. Hence, this topic is particularly under-researched in this transitional country due to the lack of research funding. However, fairly recently, a case-control study was conducted in Albania including 60 patients (30 patients with hemorrhagic stroke and 30 patients with ischemic stroke) and 60 controls (individuals without cerebrovascular pathologies) aiming at comparing the prevalence of anomalies of the circle of Willis. Patients with hemorrhagic stroke were recruited from the university Hospital Center "Mother Teresa" in Tirana, whereas patients with ischemic stroke were recruited from the Regional Hospital of Durres – one of the main districts in central Albania. All patients with hemorrhagic

stroke underwent a CT angiography procedure. On the other hand, patients with ischemic stroke underwent a magnetic resonance angiography examination. Controls were recruited from Durres Regional Hospital and consisted of individuals who did not experience cerebrovascular accidents, but exhibited signs of tension-type headache, or vertiginous syndrome. All individuals in the control group underwent a magnetic resonance angiography procedure. Findings from this study will be reported elsewhere.

Concluding remarks

Besides the development of different vascular accidents (such as aneurysms, infarctions, or other types of vascular abnormalities), it is important to identify the status of the circle of Willis in order to determine the capability of the brain circulation in operations especially for cerebral aneurysms (3,4). Similar to other countries in the world, it is important to assess the magnitude and different types of anatomical variations in adult human brains in the Albanian population.

Conflicts of interest: None declared.

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