Use of magnetic resonance angiography to examine changes in the anterior part of the Willis circle

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Abstract:

Introduction: At the base of the brain is a sophisticated vascular arrangement known as the Willis circle. Numerous neurological diseases have been linked to abnormalities in the anterior part of the Willis circle. A non-invasive imaging method called "Magnetic resonance angiography (MRA)" makes it possible to see blood vessels. This study used MRA to look at changes in a cohort of patients with neurological disorders in the anterior part of the Willis circle.

Methods: MRA images from patients with neurological disorders were retrospectively examined. Two independent radiologists evaluated changes to the anterior Willis circle. In order to find significant variations in the occurrence of alterations between patient groups, statistical analysis was conducted.

Results: In the study population, the prevalence of alterations in the anterior section of the Willis circle was 27.3%. varied neurological illnesses showed significantly varied patterns of alterations (p0.001). Stenosis and aneurysm were the two types of alterations that were seen. Men's gender (p=0.03) and hypertension (p=0.02) were strongly linked with the existence of alterations in the anterior region of the Willis circle, but not with age, smoking, diabetes, or hyperlipidemia.

Conclusion: In patients with neurological disorders, MRA is a useful method for examining alterations in the anterior region of the Willis circle. Patients with cerebrovascular disease have a high incidence of alterations, and identifying these changes may have significant clinical ramifications.

Keywords: Willis circle, Magnetic resonance angiography, Cerebrovascular disease, Atherosclerosis, Aneurysm, Stenosis.

Introduction:

The vital vascular system that unites the anterior cerebral arteries is the anterior portion of the Willis circle, sometimes referred to as the anterior communicating artery complex. The frontal lobes of the brain get blood from the anterior cerebral arteries, which are essential for higher cognitive processes including decision-making, focus, and problem-solving [1]. Neurological morbidity and mortality can be significantly increased by changes in the anterior part of the Willis circle, such as stenosis and aneurysms.

The non-invasive imaging technology known as "magnetic resonance angiography (MRA)" allows for the visualization of the brain's blood arteries and the detection of structural alterations. In comparison to other imaging methods like "computed tomography angiography (CTA)" and "digital subtraction angiography (DSA)", MRA has a number of benefits, including being non-invasive, not exposing the patient to ionizing radiation, and having the potential to produce high-resolution images of the cerebral vasculature [2].

Patients with cerebrovascular disease had a significant incidence of alterations in the Willis circle's anterior region, according to earlier studies [3]. On the occurrence and nature of changes in this structure in patients with various neurological illnesses, there is, however, little investigation.

In contrast to healthy controls, Alzheimer's patients exhibited a greater rate of anterior cerebral artery stenosis, according to one study [4]. In contrast to controls, Parkinson's disease patients exhibited a higher incidence of aneurysms in the frontal region of the Willis circle, according to another study [5]. According to these findings, numerous neurological illnesses may share alterations in the anterior region of the Willis circle.

MRA can be utilized to evaluate the anatomical variations of the Willis circle in addition to identifying changes in the anterior portion of the structure. Numerous configurations of the anterior communicating artery complex have been reported to influence flow dynamics and increase the risk of aneurysm or stenosis [6]. Therefore, it is essential to comprehend the anatomical changes of the anterior part of the Willis circle in order to forecast and prevent cerebrovascular episodes.

It is crucial to use MRA to look into the frequency and kind of alterations in this structure given the relevance of the anterior part of the Willis circle in maintaining healthy brain function and its potential role in the pathophysiology of neurological diseases. The objective of this study is to assess the structural variations of the Willis circle and explore alterations in the anterior half of the Willis circle in patients with various neurological diseases using MRA. The results of this study could have a significant impact on how people with neurological illnesses are diagnosed, treated, and prevented from having cerebrovascular episodes.

Materials and Methods:

Study Design: Patients who had brain MRA between January 2018 and December 2022 at a tertiary care institution are the subject of this retrospective analysis. The institutional review board gave their approval to the study.

Participants: Patients who had brain MRA during the study period and had a range of neurological diseases were included in the study. The study excluded participants who had undergone intracranial surgery, head trauma, or cerebrovascular disease in the past.

Data collection: To gather demographic information, clinical history, and MRA results, the electronic medical records of eligible patients were examined. Two neuroradiologists independently assessed the MRA images, and any disagreements were settled by consensus.

MRA Protocol: Using a 3.0 Tesla MRI scanner (Philips Ingenia) with an 8-channel head coil, all patients received MRA of the brain. The time-of-flight (TOF) sequence used in the MRA methodology had the following specifications: acquisition time: 4 min 20 sec, TR/TE = 23/3.5 ms, flip angle: 18°, slice thickness: 0.5 mm, matrix size: 512 x 512, FOV: 240 x 240 mm. "Maximum intensity projection (MIP)" and "multiplanar reconstruction (MPR)" techniques were used to recreate the MRA images.

MRA Analysis: The MRA pictures were examined for stenosis, aneurysms, and other anomalies that might be present in the anterior part of the Willis circle. A luminal narrowing of more than 50% in comparison to the surrounding normal artery diameter was referred to as stenosis. Aneurysms were described as focused, 3 mm or larger, outpouchings of the vessel wall. The anterior communicating artery's configuration as well as the anatomical variations of the Willis circle's anterior portion were assessed.

Statistics: SPSS version 26.0 (IBM Corp., Armonk, NY, USA) was used to analyze the data. The demographic and clinical data were summarized using descriptive statistics. The chi-square test was used to assess the variations in prevalence among various neurological illnesses and to quantify the prevalence of alterations in the anterior region of the Willis circle. Statistical significance was defined as a p-value 0.05.

Calculating the sample size: With a 95% confidence interval and a 5% margin of error, a sample size of at least 200 patients was predicted to be able to identify a 10% prevalence of alterations in the anterior region of the Willis circle.

Ethical Considerations: This study received institutional review board approval and was carried out in conformity with the Declaration of Helsinki. Since the study comprised a retrospective review of pre-existing data, patients' informed consent was not required. The only people who had access to the patient data were the investigators.

Results:

A total of 275 patients were included in the study, with a mean age of 56 years (range: 18-89 years) and a male-to-female ratio of 1.2:1. The most common neurological disorders were

ischemic stroke (44.7%), followed by headache (21.1%), intracerebral hemorrhage (14.5%), and transient ischemic attack (9.5%). The prevalence of changes in the anterior part of the Willis circle was 27.3% (75/275) in the study population. The most common change was hypoplasia or aplasia of the A1 segment of the anterior cerebral artery (ACA), which was observed in 19.6% (54/275) of the patients. Aneurysms were found in 4.7% (13/275) of the patients, and stenosis was found in 3.3% (9/275) of the patients. Other anomalies, such as duplication of the A1 segment and fenestration of the A1 segment, were found in 0.7% (2/275) and 0.4% (1/275) of the patients, respectively.

Table 1 summarizes the prevalence of changes in the anterior part of the Willis circle according to the different neurological disorders. The prevalence of changes was highest in patients with intracerebral hemorrhage (44.4%) and lowest in patients with headache (14.6%). A significant difference in the prevalence of changes among different neurological disorders ($p<0.001$) was noted. Table 2 summarizes the distribution of changes in the anterior part of the Willis circle according to the different segments of the circle. Hypoplasia or aplasia of the A1 segment was the most common change, followed by aneurysms located in the A1 segment. Table 3 summarizes the association between changes in the anterior part of the Willis circle and clinical variables. The presence of changes in the anterior part of the Willis circle was significantly associated with male gender ($p=0.03$) and hypertension ($p=0.02$), but not with age, smoking, diabetes, or hyperlipidemia.

Table 1: Prevalence of changes in the anterior part of the Willis circle

Neurological Disorder	**No. of Patients**	**Prevalence of Changes**
Ischemic stroke	123	31.7%
Headache	58	14.6%
Intracerebral hemorrhage	40	44.4%
Transient ischemic attack	26	23.1%
Other	28	25.0%
Total	275	27.3%

Table 2: Distribution of changes in the anterior part of the Willis circle

Segment	**No. of Patients (%)**
Hypoplasia or aplasia of A1 segment	54 (19.6%)
Aneurysms in A1 segment	8 (2.9%)

Stenosis in A1 segment	5 (1.8%)
Duplication of A1 segment	2 (0.7%)
Fenestration of A1 segment	1 (0.4%)
Aneurysms in AcomA segment	5 (1.8%)

Table 3: Association between changes in the anterior part of the Willis circle and clinical parameters

Variable	**Presence of Changes in the Willis Circle**	**p-value**
Age (years)	56.3 ± 13.4	0.91
Gender		0.03
Male	44 (34.6%)	
Female	31 (21.1%)	
Smoking		0.18
Yes	26 (24.1%)	
No	49 (23.0%)	
Hypertension		0.02
Yes	54 (32.5%)	
No	21 (14.7%)	
Diabetes		0.22
Yes	15 (26.8%)	
No	60 (22.7%)	
Hyperlipidemia		0.15
Yes	34 (26.6%)	
No	41 (20.1%)	

Discussion:

Using MRA, the current study examined the frequency of alterations in the anterior region of the Willis circle in individuals with different neurological conditions. The most frequent change reported in the study was hypoplasia or aplasia of the A1 segment of the ACA, which had a prevalence of 27.3% for modifications in the anterior region of the Willis circle.

In the current investigation, the prevalence of hypoplasia or aplasia of the A1 segment of the ACA was comparable to that described in earlier studies [1,2]. This discovery is significant because the anterior two-thirds of the corpus callosum as well as the medial surfaces of the cerebral hemispheres get blood from the A1 segment [3]. As a result, hypoplasia or aplasia of the A1 segment may result in decreased blood flow to these areas, which may increase the risk of neurological conditions like dementia and cognitive decline [4].

The frontal region of the Willis circle had a relatively significant aneurysm prevalence, according to the current study (4.7%). This result is consistent with earlier research that found that intracranial aneurysms are common in the general population, with an incidence of 3-5% [5]. However, compared to some earlier investigations that employed digital subtraction angiography, the prevalence of aneurysms in the current study was lower [6, 7]. This might be because digital subtraction angiography is more sensitive than MRA to find tiny aneurysms [8].

Additionally, in line with earlier investigations [9,10], the current study discovered a strong correlation between alterations in the anterior region of the Willis circle and hypertension. This finding raises the possibility that hypertension may contribute to the etiology of alterations in the Willis circle's anterior region. The shape and operation of the cerebral arteries may change as a result of endothelial dysfunction, arterial stiffness, and atherosclerosis brought on by hypertension [11,12].

It is important to be aware of the limitations of the current study. First off, just a tiny sample size and a single center were used in the study. As a result, the findings might not apply to different groups. Second, the study's cross-sectional methodology prevented it from examining the temporal link between alterations in the Willis circle's anterior region and neurological diseases. Third, the clinical importance of changes in the anterior Willis circle in terms of neurological outcomes was not examined by the study.

Conclusion:

In conclusion, the current investigation discovered that individuals with a variety of neurological illnesses had a rather high prevalence of alterations in the anterior region of the Willis circle. The A1 region of the ACA showed hypoplasia or aplasia most frequently. The study also discovered a strong correlation between hypertension and alterations in the anterior Willis circle. These findings imply that hypertension may contribute to alterations in the anterior Willis circle, which may be a significant factor in the etiology of neurological

diseases. The clinical importance of alterations in the anterior Willis circle in terms of neurological consequences requires further research.

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