PHARMACOLOGY, MEDICAL REPORTS, ORTHOPEDIC, AND ILLNESS DETAILS (COMORBID)
Volume 2 Issue 1 (2023)

IMAGING OF THE ANTERIOR COMMUNICATING ARTERY: NORMAL AND ABNORMAL FINDINGS RELATED TO ANEURYSM

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Abstract

The anterior communicating artery (AComA) is a critical component of the Circle of Willis, serving as a vital conduit that connects the bilateral anterior cerebral arteries. This study aims to provide a comprehensive overview of the imaging characteristics of the AComA, encompassing both normal variations and abnormal findings associated with aneurysm development. Utilizing advanced imaging techniques, a thorough analysis of the AComA complex was conducted in a cohort of subjects. Normal anatomical variants were meticulously documented, highlighting variations in length, diameter, and branching patterns. Abnormal findings indicative of potential aneurysm markers was carefully assessed, encompassing variations in morphology, hemodynamic flow patterns, and wall integrity. Special attention was given to elucidate the factors contributing to aneurysm initiation within the AComA complex. The clinical significance of distinguishing between normal anatomical variations and potential pathological findings was underscored, emphasizing the critical importance of early detection and intervention to mitigate the risks associated with aneurysm rupture. The findings of this study contribute valuable insights to the field of neurovascular diagnostics and therapeutic strategies. By enhancing our understanding of the AComA and its role in aneurysm development, this research aims to empower clinicians with the knowledge needed for informed decision-making and proactive management. Ultimately, the comprehensive examination of AComA imaging, encompassing both normal and abnormal variants, holds the potential to drive advancements in cerebrovascular care and improve patient outcomes.

Keywords: *Anterior Communicating Artery, Intracranial Aneurysm, Neurovascular Imaging*

1. INTRODUCTION

The intricate vascular network of the brain plays a pivotal role in sustaining its vital functions by ensuring a constant and adequate blood supply. The circulatory system responsible for this task is comprised of major arteries, including the arteria carotis interna (ICA) and arteria vertebral (VA), intricately linked through the Circle of Willis—an arterial anastomosis system. The ICA furnishes blood to the bilateral anterior cerebral arteries (ACAs) and the anterior communicating artery (AComA) for anterior circulation, while the VA nourishes the basilar artery (BA) and posterior cerebral arteries (PCAs) to sustain posterior blood supplies. This intricate arrangement serves as a safeguard, mitigating potential disruptions in cerebral blood flow. (López-Sala et al., 2020; Prince & Ahn, 2013)

Of particular significance is the role of the anterior communicating artery (AComA) in facilitating communication between the two anterior cerebral arteries. Despite its relatively diminutive dimensions—measuring around 1.48±1.45 mm in length and 1.39±0.83 mm in diameter—the AComA complex has garnered substantial attention due to its propensity to develop intracranial aneurysms. Indeed, it has been revealed that the AComA is the most prevalent site for such aneurysms, accounting for approximately 30% of ruptures. A considerable body of research has underscored the correlation between variations in the anatomical structure and hemodynamic behavior of the AComA and the initiation of aneurysms in this region. In light of the elevated morbidity and mortality associated with AComA aneurysm rupture, distinguishing between normal AComA variations and anomalies that could serve as markers for aneurysms becomes paramount. (Chen et al., 2020; Flores et al., 2013)

The present article delves into a comprehensive assessment of the normal imaging characteristics of the AComA complex, juxtaposed with abnormal imaging indicative of potential aneurysm markers. By elucidating the subtle differentiations between normal variants and potential pathological findings, this study endeavors to contribute to the early detection and proactive management of AComA aneurysms. Such insights have the potential to significantly enhance patient outcomes, minimize the risks associated with aneurysm rupture, and guide clinical decision-making in a more informed manner. The intricate interplay between the Circle of Willis, AComA, and associated aneurysm development underscores the critical importance of advancing our understanding of cerebrovascular anatomy and pathology. Through a comprehensive examination of normal and aberrant AComA imaging, this research seeks to provide a valuable contribution to the field of neurovascular diagnostics and therapeutic interventions.

2. RESEARCH METHOD

The research methodology adopted for this study encompasses a descriptive and analytical approach, combining qualitative and quantitative components to investigate the imaging features of the anterior communicating artery (AComA) in relation to both normal anatomical variations and abnormal findings associated with aneurysm development. To achieve this, a cohort of subjects is purposefully selected based on clinical criteria, and advanced neurovascular imaging techniques such as magnetic resonance angiography (MRA) and computed tomography angiography (CTA) are employed to capture detailed images of the AComA complex and its surrounding vasculature. These images undergo rigorous quantitative analysis using specialized software, enabling the meticulous documentation of normal AComA variations including length, diameter, branching patterns, and hemodynamic flow dynamics. Concurrently, potential aneurysm markers such as alterations in morphology, flow turbulence, and wall integrity are identified and characterized.

The interpretation of collected data involves both statistical analysis to reveal patterns and correlations within AComA imaging parameters, and qualitative analysis complemented by clinical insights to provide a holistic understanding of the intricate relationship between AComA anatomy and aneurysm development. The research findings are further validated through comparison with existing literature, clinical guidelines, and established diagnostic criteria, enhancing the reliability and significance of the study outcomes. Ethical considerations are of utmost importance, and the study adheres to institutional review board-approved protocols, ensuring patient confidentiality, informed consent, and research integrity.

3. RESULT AND DISCUSSION

The circle of Willis has the main fuction to supply a constant pathway of blood perfusion to the cerebrum. It holds the important role to allows the circulation sustained even if the collateral circulation is occluded or injured. The Willis circle devided as the anterior and the posterior circulation, composed by branches of arteria a. carotis interna and a. basilaris. The anterior system consist of the bilateral ACAs, part of internal carotid, and are connected by AComA. While, on the posterior, the circle consists of the two each sided PCAs which then linked by the PComA to the internal carotid arteria.(Karatas et al., 2015; Prince & Ahn, 2013; Rajan, 2021)

The ACAs is devided into three segments, well known as A1 (horizontal), A2 (vertical), and A3 (callosal). The A1 segment starts from the ICA bifurcation to the AComA. The A2 segment expanding from the junction with AComA, and the A3 segment goes to the distal where origin of callosomarginal artery.(Rajan, 2021)

The MRA imaging of the complete structure of Circle of Willis depicted in Figure 1 below.

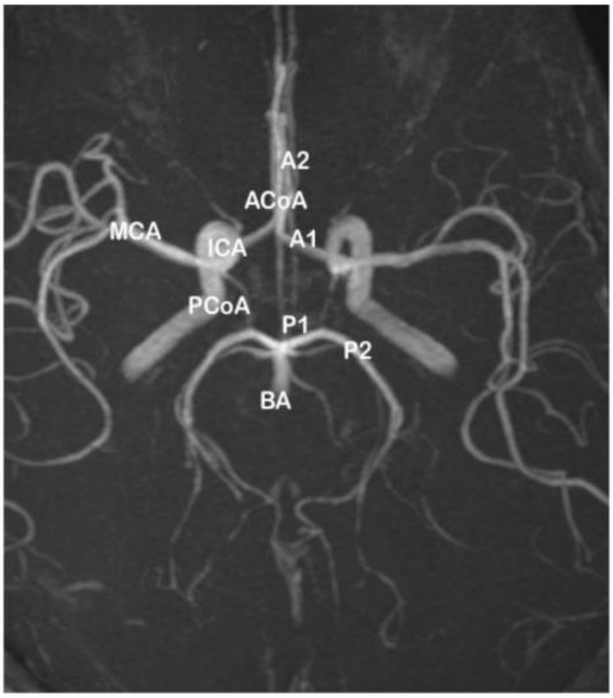

Figure 1. The magnetic resonance angiography image of The Circle of Willis, with complete vascular composition
Source: (Rajan, 2021)

However, it is a rare finding to have the complete construction of Circle of Willis, since it is only found in up to 24% of population. The process of vasculogenesis during embryological development remains as the major factor responsible due to the Circle of Willis normal variations in healthy individuals. But also, there are many anomalies variation, especially in the site of ACAs segments and AComA that have been described, such as hypoplasia, aplasia, duplication, or fenestration.(Kızılgöz et al., 2022; Krzyżewski et al., 2015; Prince & Ahn, 2013)

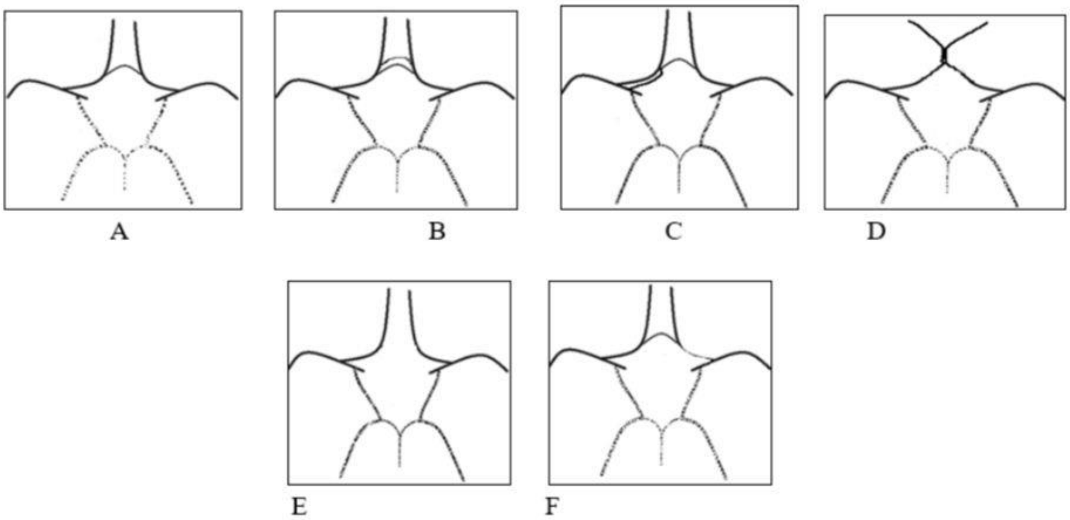

Figure 2. The variation of anterior part of the circle of Willis
Source: (Rajan, 2021)

Figure 2 illustrates the ideal, complete structure of anterior part of circle of Willis. The figure 2.B showing the apperance of multiple AComAs, while the figure 2.C showing the unilateral duplication of the A1 segment. Type D captures the scheme where the is no AComA to be seen and make a straight connection between both A1 segments. Figure 2.E shows the absence of the AComA, while Figure 2.F indicates the one sided absence (hypoplasia) of A1 segment.(Rajan, 2021)

The AComA is fuctioned as the connecting blood vessel of the ACAs and took place above the optic chiasm. The AComA is devided into 2 categories, simple and complex variation, depending to its configuration. In general, the “simple" AComA length ranges from 1.5–8.8mm (~4.0 mm) and 0.2–2.5 mm (~1.7 mm) of the diameter, and approximately 40% of the vessels are single. The smaller AComA diameter, the higher risk it carries to the presence of aneurysm. This diameter of the AcomA is related to the diameter of A1 dominant side, which commonly 1 mm smaller.(Chen et al., 2020; İdil Soylu et al., 2019)

Meanwhile, the “complex” type, which involved ~60% of the vessels, generally formed by 2 branches (plexiform, 33%), including the “Y,” “H,” or “X” morphology, deformity of fenestration (21%), and the dimple or “O” type (33%). In 4,5% cases, the A1 segment of the bilateral ACAs are fused, causing the absence of the AComA. In fact, there are some variations in the A1 segment, such as wide diameter differences between the A1 segment on one side to contralateral side, that may increase the potential risk to the initiation of an AComA aneurysm. The wider unequality difference between each A1 segment, the more likely it will develop an AComA aneurysm. Only 22% patients with an AComA aneurysm that have a symmetrical diameter of A1 segment of the ACA.(Chen et al., 2020; Flores et al., 2013; İdil Soylu et al., 2019; Kancheva et al., 2022)

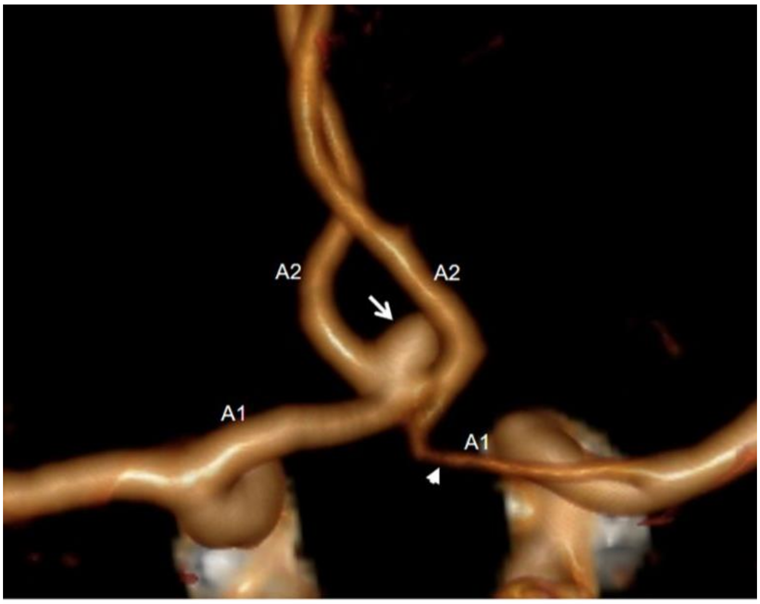

Figure 3. AComA aneurysm (arrow) with unilateral A1 hypoplasia variation (arrowhead)

Source: (López-Sala et al., 2020)

Besides of the diameter size, the ACAs bifurcation has its own hemodynamic characteristic that on many studies has been mentioned as one of the relevant factors to the formation of aneurysm. The blood streams have directly hit the apex of the juction points of the ACAs and cause high pressure in this area. The increased pressure to the vessel wall leads to the continuous hemodynamic stress that happen to cause a depravation of the membrane in the vessel wall, which more likely to get the media layer thinner. Therefore, the variation in bifurcation angle directly affects vascular wall stress that leads to the aneurysm development. Bifurcation angle may take the role on affecting blood flow direction around the area since the smaller angles of the junction most likely to disrupt the blood flow into the vortex formation to cause damage to the vessel wall and ensuing the initiation of the aneurysm. It has been reported that the A1–A2 angle was significantly narrower (103 ± 20 degrees) in patients with an AComA aneurysm than those observed in patients without aneurysm.(İdil Soylu et al., 2019; Kancheva et al., 2022; Sadatomo et al., 2013; van Tuijl et al., 2022; Zhang et al., 2018)

4. CONCLUSION

In conclusion, the intricate architecture of the circle of Willis exhibits a diverse range of structural variations, among which approximately 40% are considered within the realm of normal anatomical variants. This remarkable diversity holds a noteworthy significance in its correlation with the development of aneurysms. Notably, the anterior communicating artery (AComA) emerges as a focal point in this context, being identified as the predominant site for the occurrence of aneurysms.

The pathogenesis of AComA aneurysms is predominantly influenced by factors encompassing the bifurcation morphology, encompassing the angles and diameters of the involved vessels, and their intricate interplay with hemodynamic alterations that precipitate the initiation of aneurysm formation (İdil Soylu et al., 2019; Kancheva et al., 2022; López-Sala et al., 2020; Zhang et al., 2018). This convergence of structural and hemodynamic factors underscores the complexity underlying AComA-related aneurysm development, shedding light on a critical area of investigation in the pursuit of enhancing our understanding and management of cerebrovascular pathologies. The elucidation of these intricate relationships contributes to the broader body of knowledge and informs clinical practice, potentially paving the way for more targeted and effective therapeutic interventions in the realm of neurovascular health.

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