Anterior Communicating Artery Aneurysm Morphology and the Risk of Rupture

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Key words
- Anterior communicating artery
- Intracranial aneurysm
- Morphology
- Rupture

Abbreviations and Acronyms
ACA: Anterior cerebral artery
ACoA: Anterior communicating artery
ACoAA: Anterior communicating artery aneurysm
ICA: Internal carotid artery
MCAA: Middle cerebral artery aneurysm
SAH: Subarachnoid hemorrhage

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■ BACKGROUND: **Recently, with improvements in computed tomography angiography and digital subtraction angiography, the assessment of certain morphologic traits of anterior communicating artery aneurysms (ACoAA) has drawn great attention. The determination of specific factors associated with rupture would provide much-needed guidance for the treatment of unruptured intracranial aneurysms, such as surgical clipping or endovascular coiling. Morphologic factors include, but are not limited to, aneurysm size, number, shape, dome direction, neck/dome ratio, and relationship of the aneurysm to the surrounding vessels. However, the results of previous investigations concerning morphologic parameters have yielded inconsistent results.**

■ METHODS: **This review presents and analyzes the literature on the morphology of ACoAAs and risk of rupture.**

■ RESULTS: **This literature review reveals that the strongest predictors of ACoAA rupture are size ratio, direction of the dome, and fenestration. These were the only factors that were either unanimously or near unanimously found to be predictive of rupture across multiple studies.**

■ CONCLUSIONS: **The size ratio, direction of the dome, and fenestration should be examined most meticulously when deciding when to treat an ACoAA.**

INTRODUCTION

Intracranial aneurysms result from the bulging of arterial walls secondary to several factors including flow, vessel morphology, and genetics. Incidence rates are estimated at 2%–5%,[1-4] and rupture and subsequent hemorrhage may lead to severe consequences. Mortality and disability rates associated with aneurysm rupture are relatively high, and rupture also accounts for approximately 22%–25% of deaths attributed to cerebrovascular disease. Anterior communicating artery (ACoA) aneurysms (ACoAAs) are the most common site of intracranial aneurysms, accounting for about 30%–37% of intracranial aneurysms overall.[5] In addition, the ACoA is the most common location of intracranial aneurysm rupture, accounting for 40% of aneurysm-related subarachnoid hemorrhages (SAHs).[6-9] With the rapid development of medical imaging equipment and technology, unruptured aneurysms are readily detectable and easily characterized.[10-13] However, only 1%–2% of detected aneurysms (10–30 per 100,000 per year) progress to rupture and spontaneous SAH.[14-16] Treatment of ruptured aneurysms such as craniotomy, clipping, and endovascular embolization is risky and costly.[17-19] Thus, careful consideration of the heavy economic burden and potential iatrogenic complications of the various treatments is necessary. To develop treatment algorithms for unruptured aneurysms, factors that contribute to a higher risk of aneurysm rupture must be determined first. Once an aneurysm is identified as being high risk for rupture, surgical clipping or endovascular embolization could then be used at an early stage. Likewise, unruptured aneurysms identified as low risk for rupture could be treated conservatively.

Because it has long been believed that geometric characteristics may be used to identify dangerous aneurysms at risk for rupture, continued attention has been placed on the contribution of ACoAA morphology toward the risk of rupture.[20-23] The association between morphologic factors and rates of rupture has become a common focus of research. Despite numerous investigations pertaining to the relationship between geometric characteristics of aneurysms and rupture, only a few consistent conclusions have resulted.[24] In this analysis, we discuss the various morphologic factors that have previously been tied to ACoAA rupture, citing evidence for the strength or weakness of each factor as a predictor of rupture.

MORPHOLOGIC PARAMETERS OF ACoAA

Previously evaluated morphologic parameters of ACoAA include various continuous and categorical variables derived primarily from computed tomography angiography or digital subtracted angiography. Lin et al.[25] reported on 1 categorical and 7 continuous morphologic parameters of ruptured and unruptured ACoAA. Subsequently, Cai

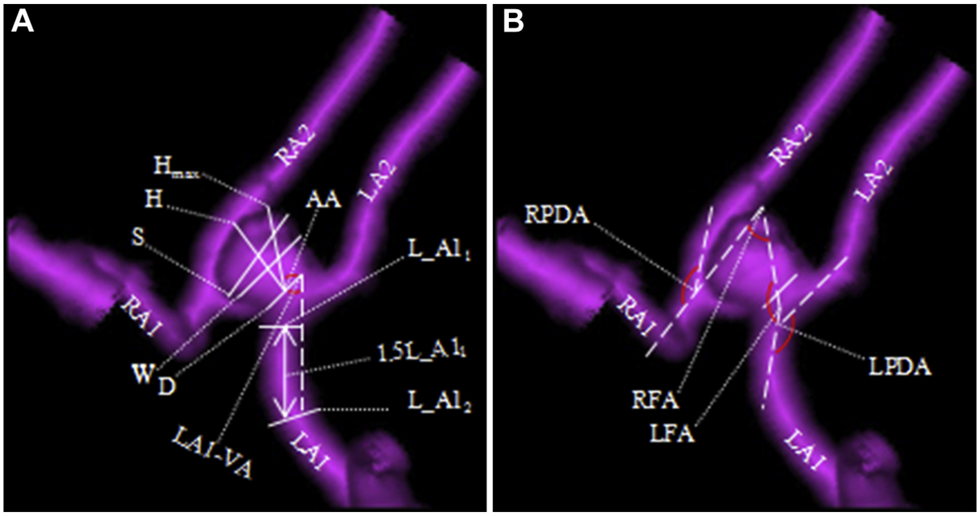

Figure 1. (**A** and **B**) The 13 continuous variables related to anterior communicating artery aneurysm morphology as determined by three-dimensional computed tomography angiography. (Reprinted with permission from Ref. 26). AA, aneurysm angle; D, aneurysm neck diameter; H, maximum vertical height of aneurysm; H_{max}, maximum height of aneurysm; LA1, left A1 segment of anterior cerebral artery; LA2, left A2 segment of anterior cerebral artery; LFA, left flow angle; LPDA, left parent-daughter angle; RA1, right A1 segment of anterior cerebral artery; RA2, right A2 segment of anterior cerebral artery; RFA, right flow angle; RPDA, right parent-daughter angle; S, aneurysm size; W, aneurysm width; VA, vessel angle.

et al.[26] investigated 9 continuous and 4 categorical computed tomography angiography–based morphologic variables while simultaneously also integrating almost all previously reported morphologic parameters. Further work by additional investigators increased the investigated number of morphologic parameters to 18, including 13 continuous and 5 categorical variables.[27-30] In review of further literature,[25-33] reported morphologic attributes of ACoAA can be summarized as follows (Figure 1): 1) aneurysm size (S), defined as maximum aneurysm diameter; 2) maximum height of aneurysm (H_{max}), defined as furthest distance from the center of the aneurysm neck to the aneurysm dome; 3) maximum vertical height of aneurysm (H), defined as maximum vertical distance from the aneurysm neck to the aneurysm dome; 4) aneurysm width (W), defined as maximum diameter perpendicular to H; 5) aneurysm neck diameter (D), defined as the maximum cross-sectional diameter of the neck of the aneurysm; 6) aspect ratio (AR), computed as the ratio between the maximum vertical height of the aneurysm and the diameter of the aneurysm neck (AR=H/D); 7) size ratio (SR), defined as the ratio between the maximum height of the aneurysm and the average vessel diameter of all of the vessels related to the aneurysm (L_A1_v, L_A2_v, R_A1_v, R_A2_v), i.e., the vessel diameter of a particular branch of L_A1_v was determined by averaging the diameter of the cross section of this vessel just proximal to the neck of the aneurysm (L_A1_1) with the diameter of the cross section at 1.5 × L_A1_1 from the neck of the aneurysm (L_A1_2), or $L\_A1_v = (L\_A1_1 + L\_A1_2)/2$, $SR = H_{max}/(L\_A1_v + L\_A2_v + R\_A1_v + R\_A2_v)/4$; 8) bottleneck factor (BF), defined as the ratio between the aneurysm width and neck diameter (BF=W/D); 9) height/width ratio (HWR), calculated as maximum vertical height divided by width (HWR=H/W); 10) aneurysm angle (AA), defined as the angle between the aneurysm neck and maximum height of the aneurysm; 11) vessel angle (VA), defined as the angle formed between the main vessel of the aneurysm and the plane of the aneurysm neck; 12) flow angle (FA), defined as the angle between the maximum height of the aneurysm and the main blood vessel; 13) parent-daughter angle (PDA), defined as the angle between the A1 artery and the ipsilateral A2 artery; 14) direction of the aneurysm dome, either anterior or posterior (this was determined by drawing a straight line parallel to the anterior cranial fossa and through the ACoAA, and then drawing a straight line perpendicular to this line to form 4 equal quadrants, with anterior defined as the 2 quadrants anterior to the second line and posterior defined as the 2 quadrants posterior to the second line); 15) shape of the aneurysm, with regular shape defined as simple saccular aneurysms and irregular shape defined as saccular aneurysms with additional daughter domes or blebs; 16) number of aneurysms, divided into single or multiple aneurysms; 17) variation of the A1 segment, including dominance of the A1 segment (defined as >33% of the difference between the A1 segment diameters[34]), as well as hypoplasia and absence of an A1 segment; and 18) ACoA fenestration, defined as the ACoA trunk dividing into 2 branches and then converging into only 1 trunk.

ANEURYSM SIZE, WIDTH, AND NECK DIAMETER

It has been widely reported that aneurysm size and width linearly correlate with the risk of rupture of ACoAA.[12,27,29,30,32] Moreover, Choi et al.[32] reported that ACoAA size >7 mm was more likely to rupture. However, rupture of smaller anterior circulation aneurysms account for