Size Ratio as a Surrogate for Risk of Aneurysmal Rupture

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LSU Health SHREVEPORT

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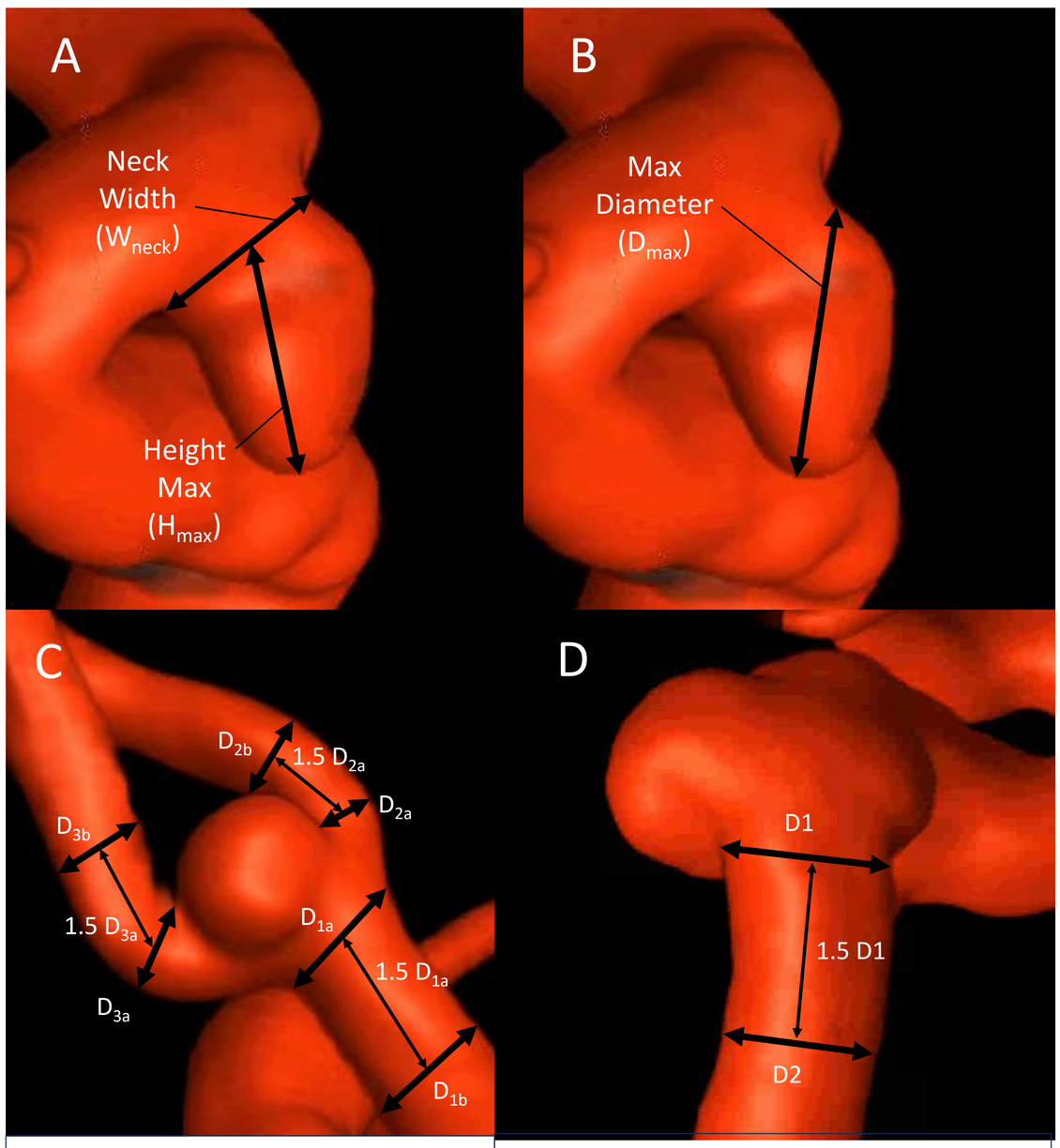
Introduction

Ruptured intracranial aneurysms cause substantial disability and mortality. For incidentally discovered unruptured aneurysms, management hinges on whether rupture risk outweighs treatment risk. Although absolute aneurysm size is commonly used in clinical decision making, its predictive value has been questioned.

Size ratio (SR), an aneurysm dimension indexed to **parent artery caliber,** may better reflect local hemodynamics and wall stress than size alone. In this study, we evaluated whether SR more effectively discriminates rupture status compared with maximal diameter or height of the aneurysm.

Methods

- **Study design:** EHR based retrospective cohort
- **Population:** Ruptured and unruptured intracranial aneurysms with 3D-DSA (2019–2024)
- **Measurements:** Caliper measurements done independently by two reviewers
  - Geometry measurements and SR equations defined in **Fig. 1**
- **Statistics:** Continuous data reported as median (IQR); categorical associations reported as OR



E **Parent Vessel Diameter**

Side Wall (Panel D)

$$D_{parent} = \frac{D_1 + D_2}{2}$$

Bifurcation (Panel C)

$$D_{parent} = \frac{D_{v1} + D_{v2} + D_{v3}}{3}$$

$$D_{vi} = \frac{D_{ia} + D_{ib}}{2}$$

F **Derived Aneurysm Geometry Equations**

$$SR_1 = \frac{H_{max}}{D_{parent}}$$

$$SR_2 = \frac{D_{max}}{D_{parent}}$$

$$AR = \frac{H_{max}}{W_{neck}}$$

Figure 1. Aneurysm measurements and size-ratio definitions. Panels A–D depict measurement of **(A)** maximum height and neck width, **(B)** maximum diameter, **(C)** parent vessel diameter for bifurcation aneurysms, and **(D)** parent vessel diameter for side-wall aneurysms. Panels **E–F** show equations for average parent vessel diameter (D_parent), both definitions of size ratio (SR1, SR2), and aspect ratio (AR).

Results

- **Cohort**: 84 patients (53 unruptured, 31 ruptured)
- **Size metrics** (ruptured vs. unruptured)
  - SR1: 2.22 [1.29, 3] vs 1.30 [0.86, 1.92], **p < 0.01**
  - SR2: 1.70 [1.07, 2.57] vs 1.07 [0.85, 1.92], p=0.052
  - AR: 1.63 [1.11, 2.06] vs 1.22 [1.01, 1.71], p=0.054
  - Max diameter: 3.82 mm [2.7, 5.02] vs 3.31 mm[2.31, 4.8], p=0.52
  - Max height: 4.30 mm [3.15, 6.96] vs 3.60 mm [2.41, 5.8], p=0.15
- **Patient factors**
  - Female sex: OR 0.61, p=0.39
  - Hypertension: OR 1.00, p=0.99
  - Family history: OR 1.76, p=0.63
  - Bifurcation status: OR 1.22, p=0.66

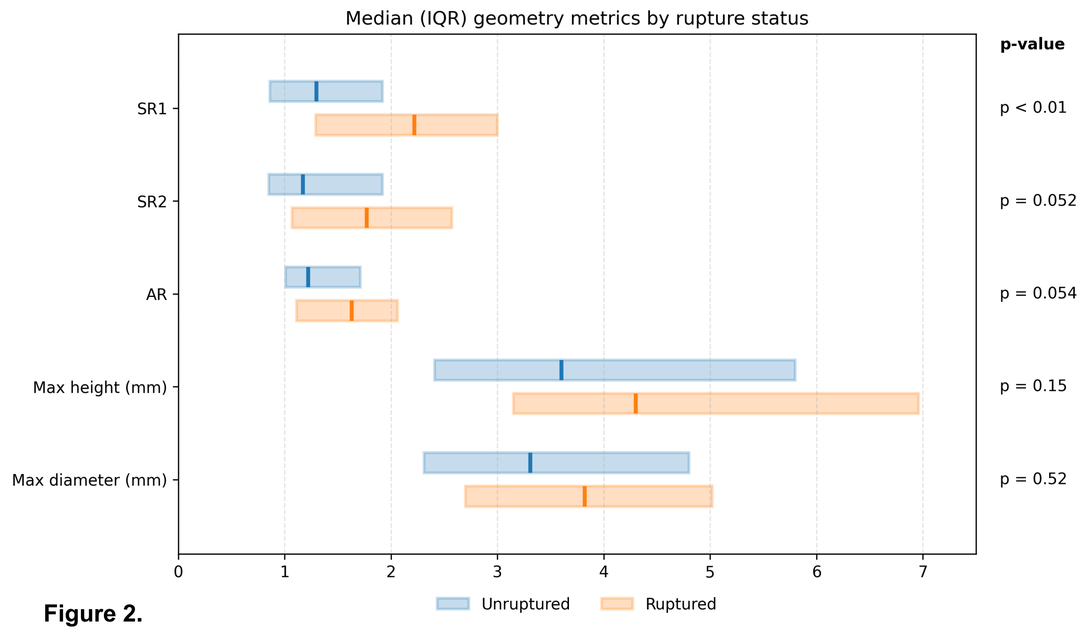


Figure 2.

Discussion

- In this retrospective 3D-DSA cohort, size ratio (SR) and aspect ratio (AR) separated ruptured from unruptured aneurysms better than absolute size alone.
- SR1 (H_max / D_parent) demonstrated the strongest discrimination, with size ratio significantly higher in ruptured vs unruptured aneurysms **(p < 0.01)**.
- In contrast, maximum diameter and maximum height did not significantly differ by rupture status (p = 0.52 and p = 0.15, respectively), suggesting that absolute dimensions may be less informative than SR
- SR2 (D_max / D_parent) and AR (H_max / W_neck) did not meet conventional significance thresholds, but both showed near-significant trends (p = 0.052 and p = 0.054). This pattern may reflect limited statistical power and supports additional evaluation of SR2 and AR in larger cohorts.
- Traditional patient/anatomic factors examined such as sex, hypertension, family history of aneurysmal rupture, and bifurcation status were not associated with rupture status in this cohort.
- Collectively, these findings support incorporating vessel-normalized morphology (particularly SR1) into future rupture-risk modeling and encourage standardized measurement definitions to improve comparability across studies.

Conclusions

In this single-center cohort of 84 aneurysms, size ratio (SR) outperformed maximal diameter and height in discriminating rupture status. SR1 (maximal height ÷ parent artery diameter) demonstrated a statistically significant difference between ruptured and unruptured aneurysms, whereas SR2 and aspect ratio showed near-significant trends. These results support further validation of SR—particularly SR1—as a standardized rupture-risk metric, and they underscore the importance of clearly specifying parent artery diameter measurement methodology in SR-based studies.

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