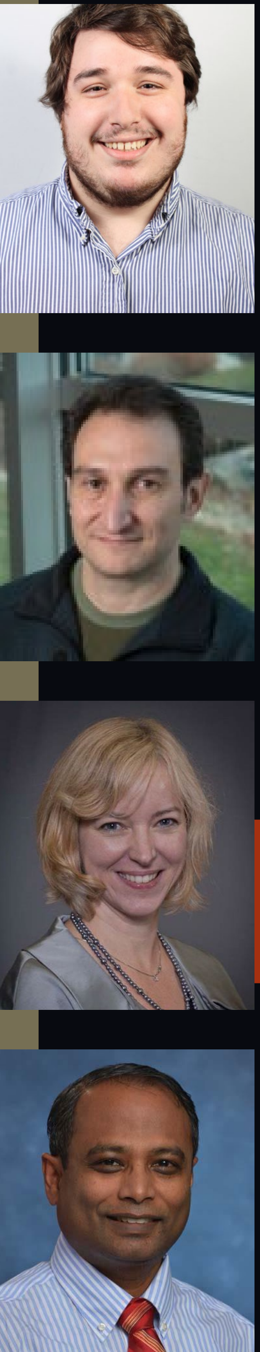


Funding Sources
1R01-NS097457-01
5T32HL076124-12

Using In-Vivo Morphological Measurements of Cerebral Aneurysm Blebs to Predict Aneurysm Rupture Risk

Ronald Fortunato(1), Juan Cebral(2,3), Anne Robertson(1,4), Spandan Maiti(1,4,5)

(1)Department of Mechanical Engineering and Materials Science, (2) Department of Bioengineering, George Mason University, Fairfax, Virginia, USA, (3)Department of Mechanical Engineering, George Mason University, Fairfax, Virginia, USA, (4)Department of Bioengineering, (4)Department of Chemical and Petroleum Engineering, University of Pittsburgh, Pittsburgh, USA

Introduction

- Intracranial aneurysms (IA), the pathological enlargement of the cerebral arterial wall, are present in 3-8% of the adult population [1,2]
- Spontaneous rupture of cerebral aneurysms is extremely fatal, ~45% mortality rate, while survivors suffer from disabilities [3,4]
- Current risk-based metrics used to guide clinical decisions of treatment versus observation, such as the PHASES score [5], include patient demographics (Age, Gender, Hypertension, etc.) but incorporation of the morphological structure of the aneurysm is limited to aneurysm size
- Blebs are focal bulges or daughter-sacs of the parent aneurysm and their presence is known to indicate increase risk of rupture [6]

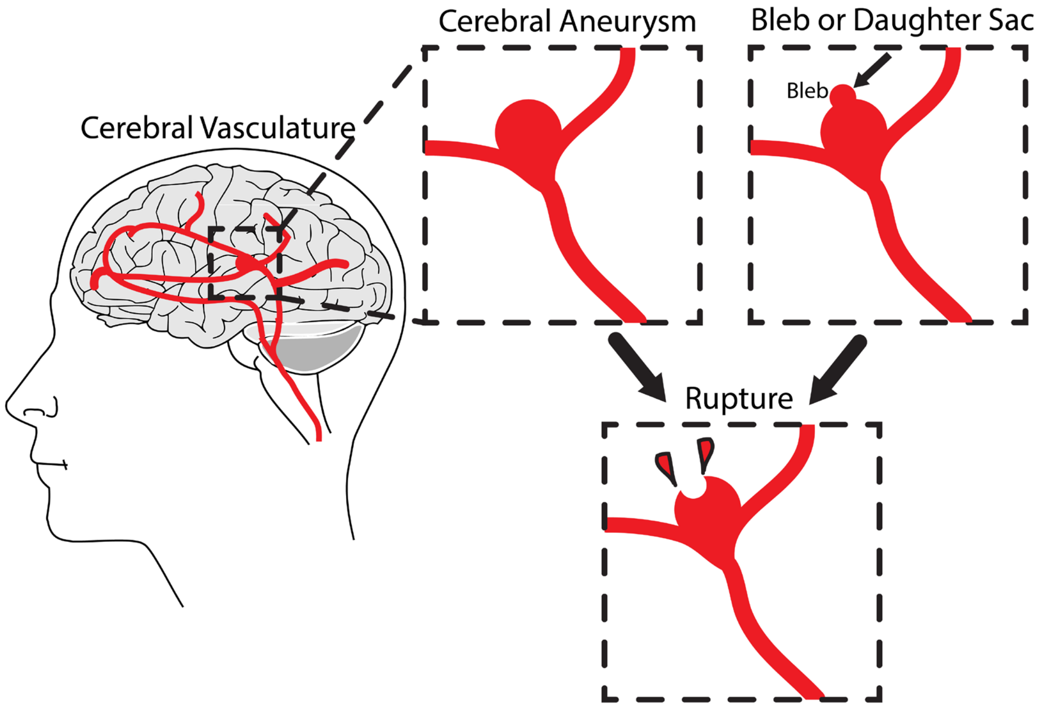


Figure 1: Schematic of saccular cerebral aneurysm and rupture. Presence of blebs or daughter sacs as appendages of the parent aneurysm are traditionally thought to increase risk of rupture

Methods

- N=35 were included in this study
  - three-dimensional rotational angiography or computed tomographic angiography
  - patient record of aneurysm rupture status
- From those clinical image's patient-specific cerebral vasculature surfaces were created
- Surface curvature was calculated using a least-squares quadratic patch method using a 3-ring vertex neighborhood to construct the patch
- We used an inter-observant agreed method to identify which elements on the vasculature surface belonged to the bleb
- We calculated two global surface curvature metrics: the L2-norm of the Gaussian curvature (GLN) and L2-norm of the mean curvature (MLN) of blebs
- Receiver operator curves (ROC) and thereby area under curves (AUC) were calculated of those global metrics for each patient in either the rupture or unruptured cohorts.

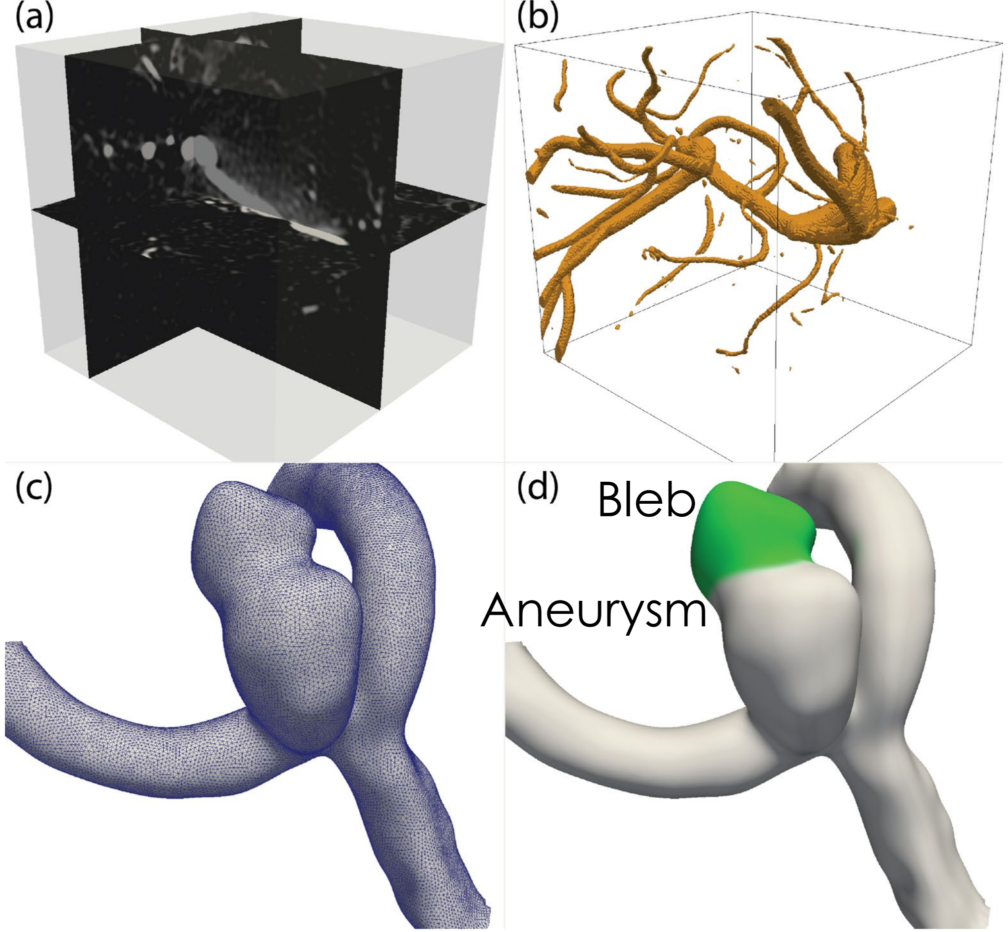
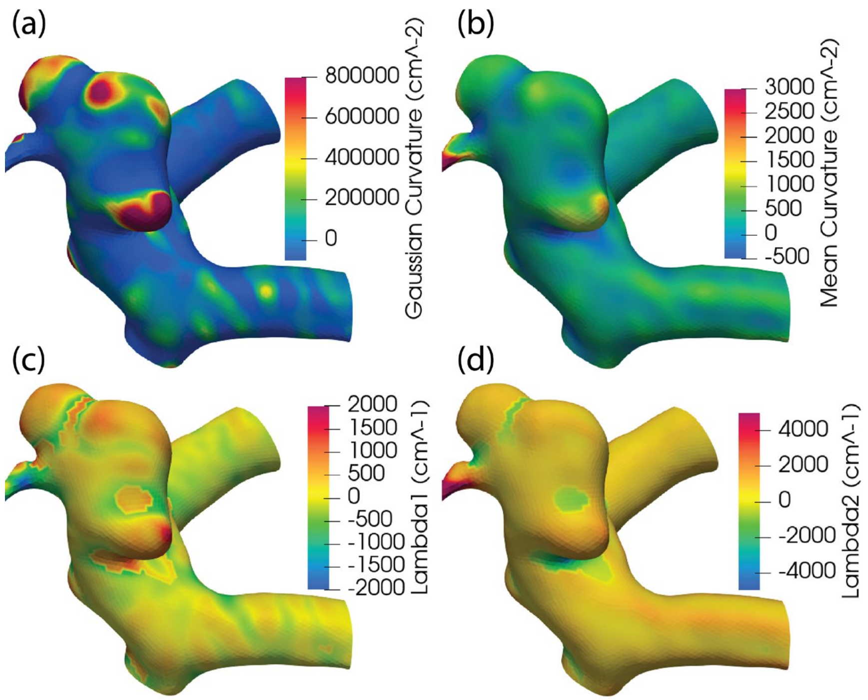
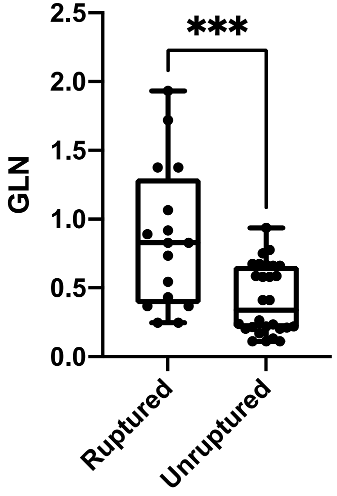
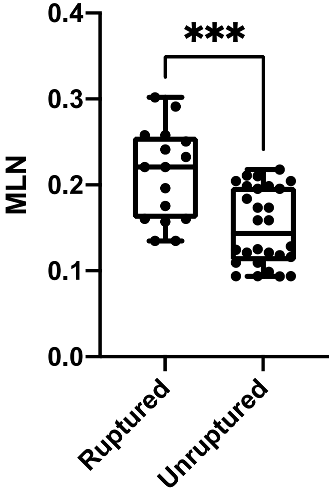


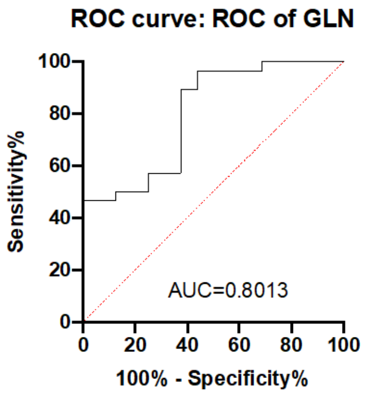
Figure 2: (a) 3-D rotational angiography images are ordered by physician and transferred to PACS system (b) Segmentation of cerebral vessels using threshold filter creates isosurface (c) Isosurface is smoothed and meshed with triangle elements (d) Bleb is identified, shown in green here, via an inter-observer agreement method

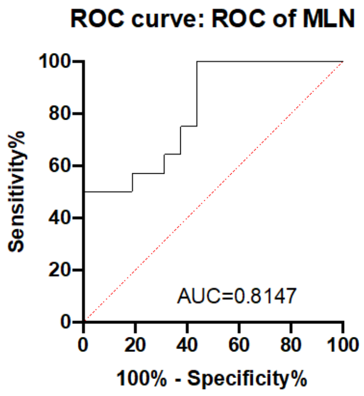
Results











- The significant difference in MLN and GLN in blebs that have records of rupture status provides a good non-invasive discriminating factor and possibly a predictor of aneurysm rupture
- Additionally, we are investigating the relationship between morphological features and their effects on biomechanics of the aneurysm wall through finite element analysis