NUMERICAL MODELLING OF THE MASS TRANSPORT OF BLOOD-BORNE SPECIES IN CEREBRAL ANEURYSMS OF THE SYLVIAN BIFURCATION

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Introduction

The rupture of cerebral aneurysms can have devastating effects (Schievink 1997). Although the exact mechanisms behind their formation, growth and rupture are unknown, it is believed that hemodynamics plays an important role (Sforza 2009). The hypothesis motivating this study suggests altered hemodynamics may lead to a lack of species at localised regions throughout the aneurysm wall, resulting in negative wall remodelling, weakening, growth and possible rupture. The aims of this study are two-fold: firstly, to develop representative geometries of the sylvian bifurcation based on patient-specific models and evaluate their efficacy in representing realistic models, and secondly to undertake a numerical analysis of the changes in concentration of species at the aneurysm wall.

Methods

From a cohort of 237 patient-specific cerebral aneurysms, it was determined that 37 (15%) were found at the sylvian bifurcation (Fig.1A). Each geometry was measured for key geometric parameters (see Fig.1B). The average artery diameters (Table 1) were swept over their centrelines to create a representative geometry of a sylvian bifurcation aneurysm.

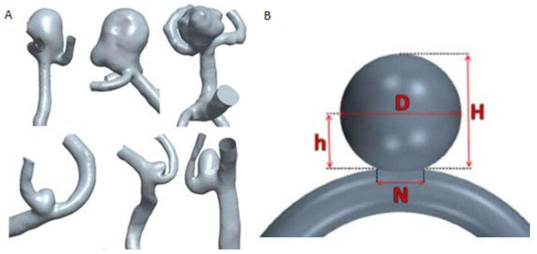

Figure 1: (A) Example of patient-specific Sylvian Bifurcation Geometries and (B) Aneurysm Parameters Measured

The Computational Fluid Dynamics solver Comsol Multiphysics 4.2a was utilised for the hemodynamics and mass transport analysis of the changes in species concentration at the aneurysm wall over time.

Results

Parameter	Average Value (± Std. Dev.)	Parameter	Average Value (± Std. Dev.)
Height (H) (mm)	5.23 ±2.80	**Volume (mm^3)**	1.14E-07 ± 1.767E-07
Neck Width (N) (mm)	4.53 ± 1.58	**PA Inlet D(mm)**	2.55 ± 0.46
Diameter (D) (mm)	4.63 ± 2.23	**PA Outlet 1 D(mm)**	2.08 ± 0.31
Distance from Neck to Diameter (d) (mm)	1.60 ± 1.83	**PA Outlet 2 D(mm)**	1.78 ± 0.39

Table 1: Averaged Sylvian Bifurcation Aneurysm Parameter Values (PA = Parent Artery, D = Diameter)

Discussion

Results from the mass transport simulations show that, as expected, areas of stagnated flow within the aneurysm sac typically display low concentrations of blood-borne species, increasing the risk of aneurysm rupture.

Variation of the key geometric parameters outlined in Table 1 gives improved information regarding the mass transport of blood-borne species to specific locations within the aneurysm sac, helping to identify key features that may be associated with aneurysm rupture.

Positive correlation is seen between mass transport results for representative and patient-specific results, displaying the efficacy of representative models as an alternative to patient-specific models.

References

W.I. Schievink, *N Engl J Med* 336:28-40, 1997.

D.M. Sforza et al., *Annu Rev of Fluid Mech*, 41:97-107, 2009.