Pressure and Flow Interplay in Aortic Dilatation using 4D Flow Magnetic Resonance Imaging

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Aims: The understanding and the prediction of ascending thoracic aortic aneurysms (ATAA) progression are not well established yet and aortic dissection is frequently occurring on normally sized and mildly dilated aortas. Despite known theoretical associations between pressures and blood flow patterns there are no studies focusing on their simultaneous evaluation. Our aim was to propose a comprehensive and quantitative evaluation of pressure-flow-wall interplay from 4D flow MRI in the setting of aortic dilation.

Methods: We studied 12 patients with ATAA (67±14 years, 7 males) and 12 healthy subjects (63±12 years, 8 males) who underwent 4D flow MRI. The segmented velocity fields were used to estimate: 1) local ascending aorta (AA) pressure changes from Navier-Stokes-derived relative pressure maps (AADP, mmHg), 2) AA wall shear stress (AAWSS, Pa) by estimating local velocity derivatives at the aortic borders, 3) aortic flow vorticity using the λ2 method (AAV, s^{-1}).

Results: AA local pressure change (AADP) was significantly associated with both AAV (r=0.55, p=0.006) and AAWSS (r=0.69 p<0.001). Both associations remained significant after adjustment for diameter, age and BSA (p = 0.007 and p=0.003 respectively). Such positive associations indicate that local pressure variations affect local blood flow, generating flow current from high to low pressures and subsequently vortices with the underlying stress exerted on the AA wall.

Conclusion: Local variations in pressures within the aorta, rendered possible while using 4D flow MRI, are associated with flow disorganization as quantified by vorticity and with the increase in the stress exerted on the aortic wall, as quantified by wall shear stress.

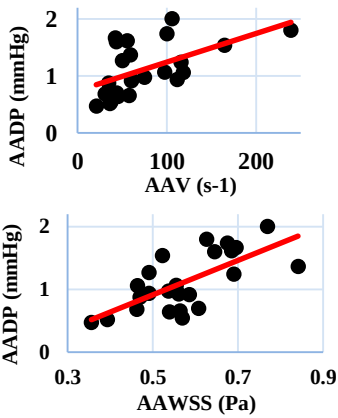

Figure: associations between local pressure difference (AADP) and AA vorticity (AAV) (top) as well as AA WSS (AAWSS) (bottom).