Assessment of Patient-Specific Heamodynamic Forces in Transcatheter Mitral Valve Replacement Patients

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Aims: In transcatheter mitral valve replacement the regurgitant mitral valve is replaced with an artificial bioprosthetic. This bioprosthetic is subject to heamodynamic forces within the ventricle that may affect its stability and anchoring. We aim to compute these forces during systole to provide non-invasive assessment of haemodynamic efficiency.

Methods: Three dimensional computational fluid dynamics (CFD) simulations are performed using the software package STARCCM+ in 3 patients with a similar size of outflow tract but different ejection fraction. The heamodynamic forces are obtained as a volume integral of fluid momentum. The force exerted on the prosthetic is also calculated throughout the cycle (Figure 1, A).

Results: The heamodynamic force vector is displayed at peak systole on a slice that intersects the apex and the aortic and mitral valves for the three patients (Figure 1, A, B, C). The angle between the axis of the outflow tract and the direction of the peak systolic force is 10.96°, 8.96°, and 27.75° for patient 123-001, 123-003, and 123-015 respectively. Patient 123-015 exhibits a maximum force on the valve that is 2.5 times larger than that observed in patient 123-003 (Figure 1, D). These results suggest that the force experienced by the valve is affected not just be the magnitude of the pressure gradient in the outflow tract but also by the direction of the force vector in relation to the position of the prosthetic in the outflow tract, which ultimately results from the contraction patterns.

Conclusion: Patient-specific flow simulations show that heamodynamic forces in the valve region can vary substantially between patients even when anatomical measurements such as the outflow area are similar. Identifying correlations between heamodynamic forces and the wall motion may provide a mechanistic interpretation of mechanical abnormalities and potentially predict the occurrence of cardiac remodeling.

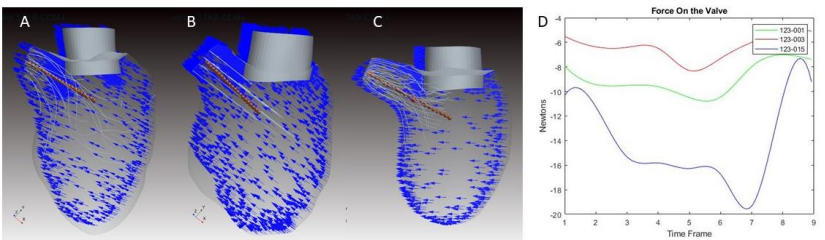

Figure 1- A:C peak systolic slice with glyphs representing the heamodynamic force and the LVOT axis (red), D the force acting on the valve over the cardiac cycle