Computational study to assess hemodynamic forces in descending thoracic aortic aneurysm

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Abstract:
Descending Thoracic Aortic Aneurysm (DTAA) is defined as a localized diameter increase of the descending thoracic aorta. TEVAR is a minimally invasive DTAA treatment based on the deployment of a self-expandable stent-graft. To avoid device migration, it is important to identify the correct Landing Zones (LZs) where to perform the stent-graft sealing. In this context, we propose a Fluid-Structure Interaction (FSI) computational framework with the aim of assessing the DTAA hemodynamics and providing quantitative information, at the pre-operative level, useful to predict TEVAR outcomes.
Our FSI framework includes a turbulence model and two different Young's Moduli for the healthy and the aneurysmatic portion of the aortic wall, considering DTAA stiffer. In our analysis, we propose also a risk index useful to correlate hemodynamic forces with the risk of stent-graft migration associated to each LZ.
We first build nine DTAA ideal scenarios varying the Aortic Arch (AA) type and the aneurysm ubication. Our findings demonstrate that DTAA hemodynamics is profoundly disturbed, with the presence of flow recirculation and transition to turbulence, especially in configurations with a steeper AA. We notice an increase of pressure in configurations with less steep AA and of drag forces for configurations with distal DTAA. In all the configurations, the risk index shows the greatest values in the aneurysm and, for each configuration under study, we try to suggest the most suitable LZs for the device sealing.
Then, we apply our methods to three patient-specific models built by segmenting pre-operative CTA scans of patients who underwent TEVAR. Results in such cases show great affinity with the corresponding ideal scenarios, highlighting that specific morphological feature of DTAA play an important role in hemodynamics and its effects.
Our pre-operative analysis might be a useful tool for clinicians to identify suitable LZs to perform a correct stent-graft sealing.