A novel imagery-based method for preoperative EVAR/TEVAR modeling: validation

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Target audience: Physicians and scientists interested in predictive methods for endovascular aneurysm repair.

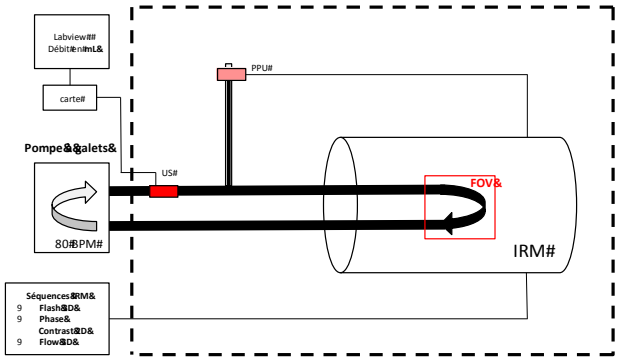
Introduction

The multilayer flow modulator (MFM) was introduced as an alternative minimal invasive treatment for arterial and aortic aneurysms (Cardiatis, Isnes, Belgium)[1]. The principle of flow modulation is to reduce flow velocity and vorticity in the aneurysmal circulating volume, while enhancing laminar flow in collateral arteries. Although the concept had been proven, treatment in certain clinical cases was not conclusive. This work shows the validation of a methodology which combines preoperative imaging and Computed Fluid Dynamics (CFD) in order to forecast the becoming of a MFM stent graft.

Material and Methods

Our methodology combines a 3D MR morphological data acquisition (3D FLASH), an axial-slice 2D phase-contrast acquisition (flow measurement before the aneurysm), and CFD numerical modelling. This latter was performed using a CFD solver (Yales2bio, Montpellier, France) which exploit the 3D morphological data and the flow measurement.

For the method validation, velocity was measured using isotropic-voxel (1mm) time-resolved 3D flow MRI[2] (venc=0.25m/s, duration=1h33). The MRI-compatible test-bed consisted in a closed-loop circulating system including a 3D-printed abdominal aortic aneurysm with a collateral way, the flow being pulsed by a pump (Fig. 1). The flow value was controlled by an ultrasonic sensor serially integrated within the circulating system.



Results

Fig. 2 displays a slice of CFD outcomes and MRI velocity data (*Paraview 4.2.0*) for visual assessment. Accuracy assessment revealed a discrepancy < 12% between CFD and MRI measurements, especially in the interquartile range (Fig. 3). Our methodology enabled to illustrate real situations using imaging exams.

Discussion

The results demonstrate that CFD is a suitable tool for predicting the flow in a circulating system, using MR 3D morphological and 2D velocity data. We are pursuing this work with an analysis of the flow within the 3D-printed AAA, with and without an MFM.

References: 1. Sultan et al., *J Endovasc Ther*, 2013 - 2. Markl et al., *J Magn Reson Med*, 2007

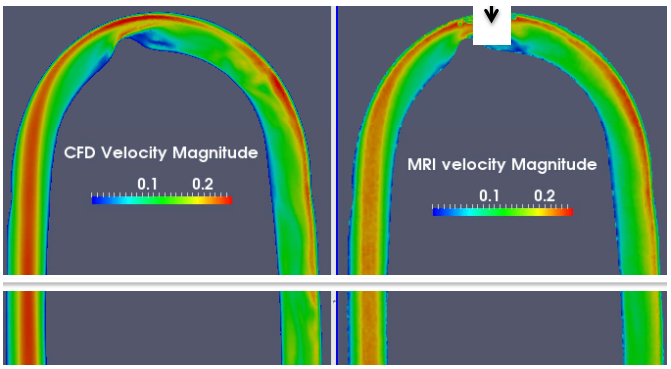


Fig.2. Display of CFD *(left)* and MRI *(right)* velocity measurement. Phase wraps is indicated by the arrowhead

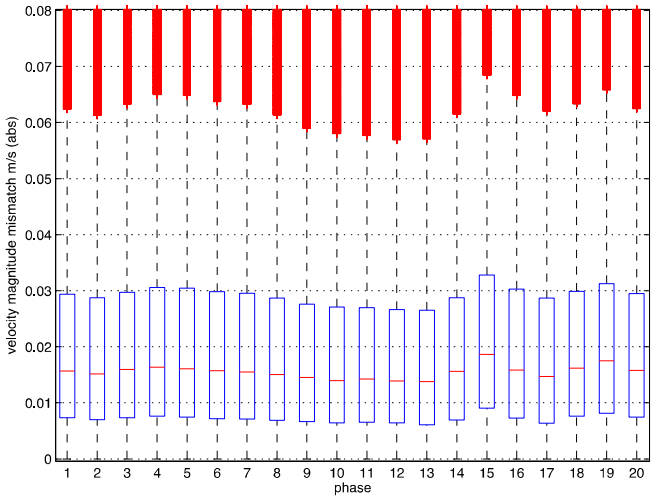


Fig. 3. Boxplot of discrepancies between CFD and MRI flow measurement for all the acquired cycles.