Hemodynamic Variations Induced by Fenestrated Endovascular Aneurysm Repair

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Background

Fenestrated endovascular aneurysm repair (FEVAR) is often used to treat patients with abdominal aortic aneurysms (AAA) to avoid an aneurysm rupture with a stent-graft device. However, whether hemodynamic changes occur once the customized stent-graft is inserted remains unclear.

Methods

Computational fluid dynamics (CFD) simulations are conducted using SimVascular to characterize hemodynamic changes after FEVAR. Computed tomography angiography (CTA) images of before and after FEVAR are used to create patient-specific geometries. Incompressible Newtonian fluid is assumed for blood with density of 1060 kg/m³ and viscosity of 0.004 kg/ms. Transient laminar simulations were conducted with 8 flow cycles. Timestep size was set to 0.000502319 s. Boundary conditions consist of a Womersley velocity profile with a flow waveform from Les et al. and 3-element Windkessel models on all branch outlets. Mean pressure and oscillatory shear index plots are post-processed from slightly coarser mesh cases.

Results

Flow and pressure changes in the post-FEVAR case were minimal with the exception of the hepatic artery and left renal artery. Mean and max flow rates in the hepatic artery increased by 1.6% and 10.6% respectively, with an approximately 3% increase in peak pressure. Max flow rate and peak pressure in the left renal artery decreased by 2.6% and 1.5% respectively although mean values ranged from only 0.5-0.6%.

Discussion

The large peak pressure and flow rate change in the hepatic artery is somewhat surprising. The left and right renal arteries were expected to differ much more than what the CFD simulation results would seem to suggest.

Peak flow rate and pressure can increase by up to 10.6% and 3.0% in the hepatic artery after FEVAR.
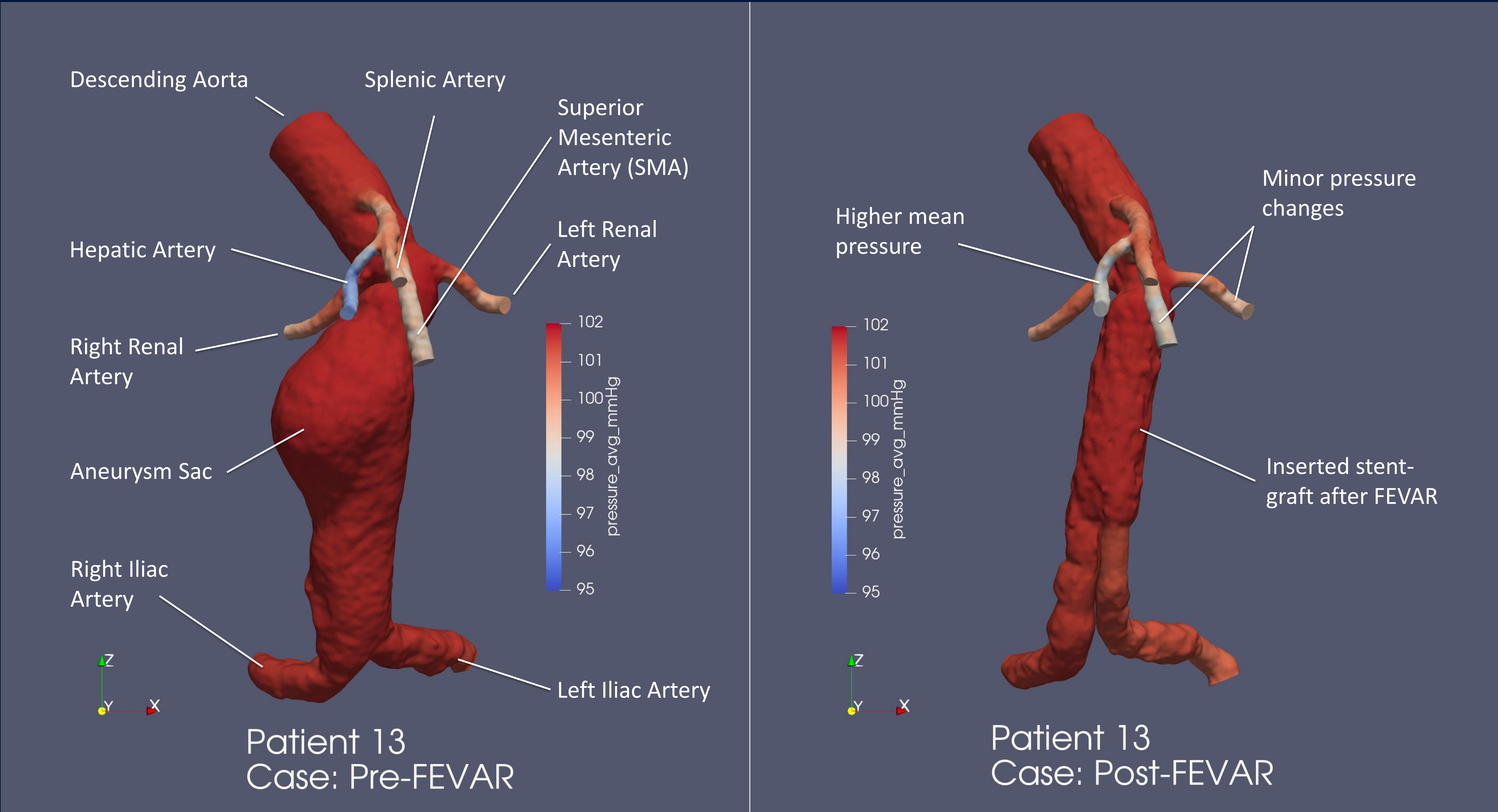
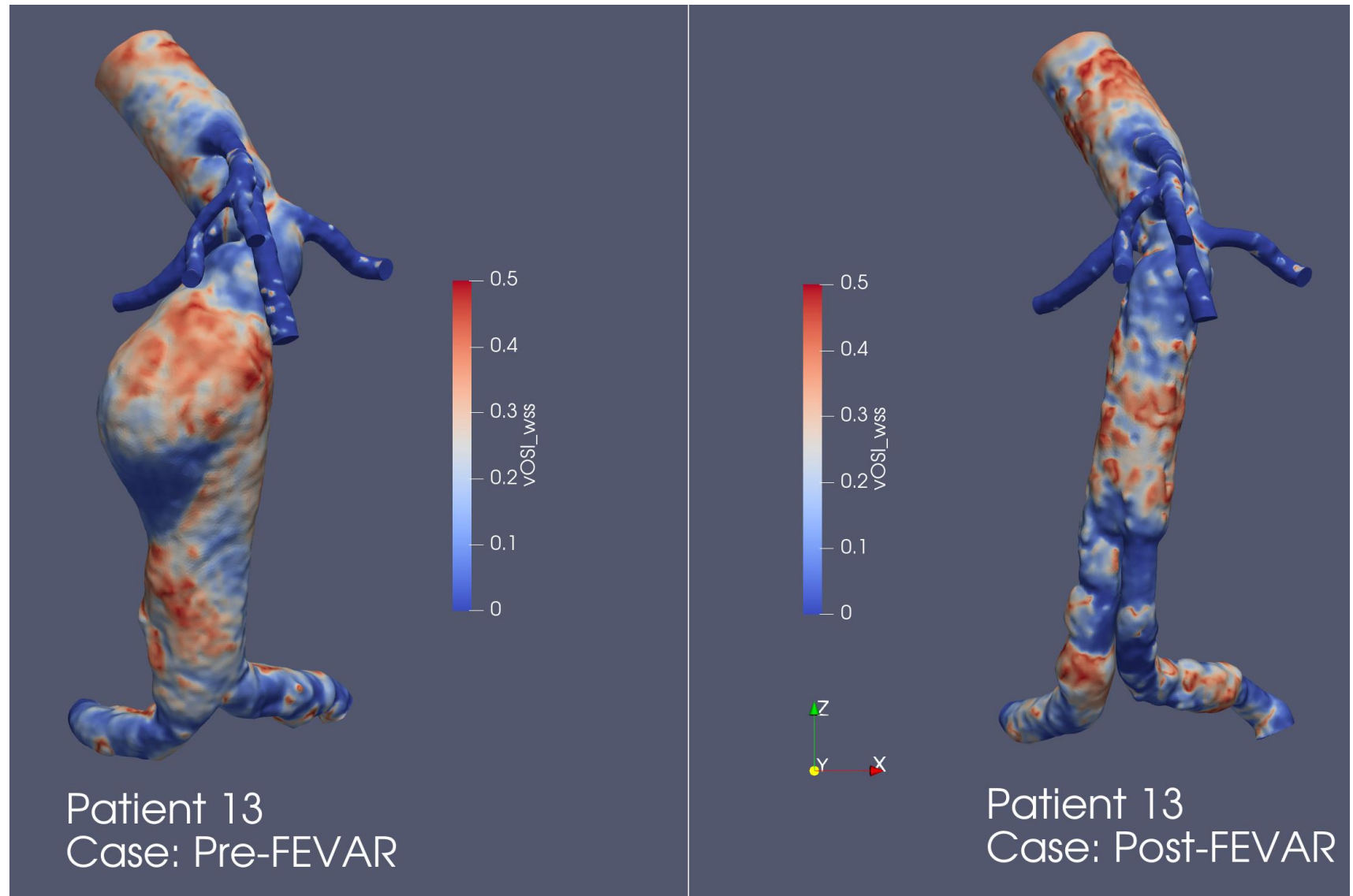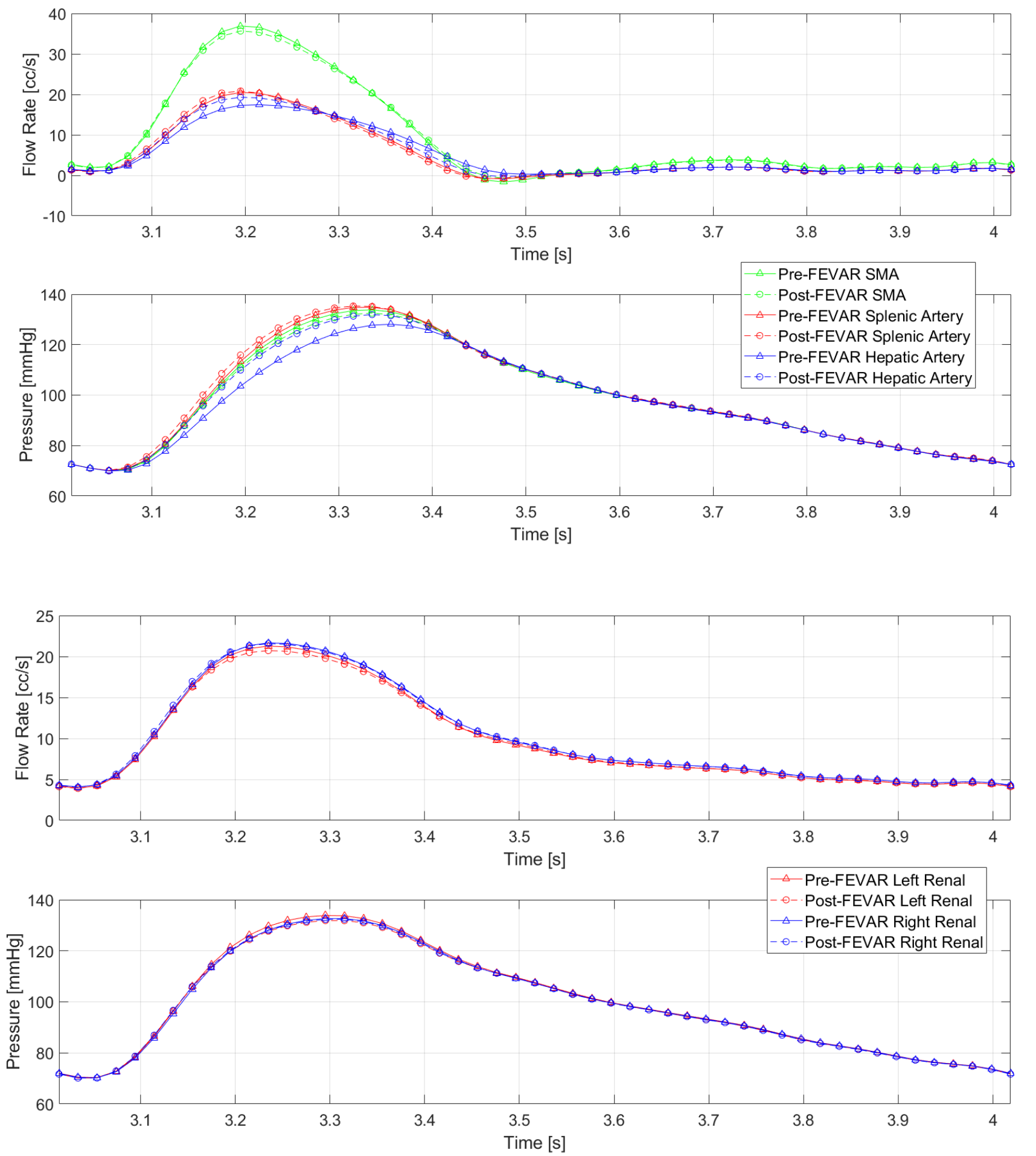

Fig. 1: Mean pressure in mmHg before and after FEVAR in cycles 5-8.

Fig. 2: Oscillatory shear index (OSI) before and after FEVAR.

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