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IN VITRO ASSESSMENT OF ABDOMINAL AORTA NON-NEWTONIAN HEMODYNAMICS BASED ON PARTICLE IMAGE VELOCIMETRY

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Introduction

Aortic Dissection (AD) is a condition in which the inner layer of the vessel tears causing separation between the inner and middle layers of the aorta. Blood surges into the tears, resulting in vulnerable secondary blood flow channel. Surgery consists in positioning a stent graft in the damaged area to reinforce vessel walls and redirect flow [1]. Tears, surgical tools insertion and stent graft positioning generate flow field disturbances that may influence the evolution of the disease. Many studies have investigated flow disturbances in Abdominal Aorta (AA) under healthy, dissection and post-surgical conditions with the use of AA phantom [2-4]. However, non-Newtonian behaviour is rarely investigated in such aorta phantom. The current study focuses on replicating AA non-Newtonian flow patterns in pathological and stented AA compliant phantoms.

Methods

Abdominal Aorta model: experiments were conducted on a compliant silicon model of an abdominal aorta extended to iliac arteries. The model was shaped based on a patient abdominal MRI.

Flow pulsatile cycle: a helical pump and a proportional solenoid valve controlled with LabVIEW program (LabVIEW 2017, National Instrument, US) regulate flow rate and ensure its pulsatile behaviour. Pressure and flow rate are both monitored upstream and downstream the model (Fig. 1).

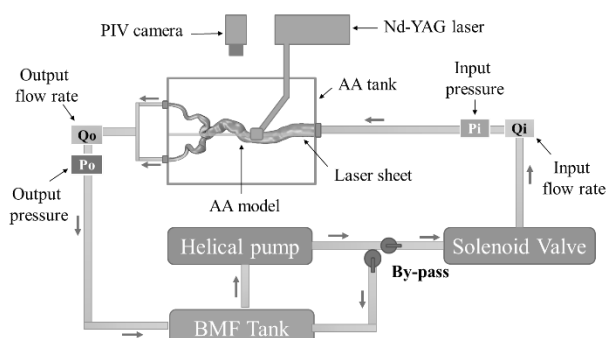


Figure 1: Top view of the experimental set-up. Arrows describe flow direction in the circuit.

Blood mimicking fluid (BMF): in order to approach blood rheology, a non-Newtonian blood mimicking

fluid was obtained with Xanthan polymers and glycerol solution.

Particle Image velocimetry: flow fields are assessed by lighting the fluorescent particle-seeded fluid with pulsed Nd-YAG laser sheet (Nano L120-20 PIV, 532 nm, Litron Lasers). The model is immersed in a tank containing same BMF to prevent light distortion. A camera captured particles position at different flow cycle instants.

Results

Pulsatile flow was successfully replicated in a AA compliant model with respect to flow rates and blood properties. Assessed flow fields are described on Fig.2.

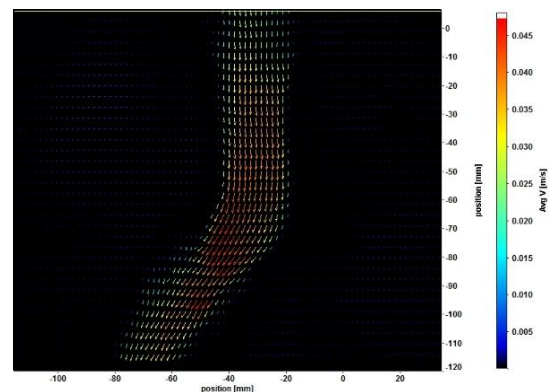


Figure 2: Flow fields in AA model at a replicated cardiac cycle instant.

Discussion

Description of in vitro non-Newtonian flow fields was achieved in an AA phantom. However, results are limited to a specific healthy patient AA geometry. Therefore, the tank was designed to host various shape of aortic models. The current AA model will be replaced with AD models (from thoracic and abdominal aorta) while maintaining the same flow pattern. Similar PIV assessment are to be conducted on the AD model before, during and after stent graft positioning by combining the circuit with a controlled stenting system.

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