Chair: Physics of Fluids group

Does blood flow influence the outcome of endovascular abdominal aneurysm repair?

Description

Endovascular aneurysm repair (EVAR) is the dominant treatment strategy for infrarenal abdominal aortic aneurysms (AAA). Despite the good short term results, the success of the procedure is impeded in 1.2 to 6.4% of the cases by endograft limb occlusion [1]. Claudication and acute limb ischemia are common consequences of limb occlusion, with severe impact on the quality of life of the patient and reintervention is then often indicated or necessary. Pre- and post-operative predictors for limb occlusion are necessary to prevent the need for such extreme measure and currently entirely lacking, despite rigorous follow-up procedures.

The Medisch spectrum Twente (MST) mainly uses the Anaconda graft (Vascutek, Figure 1). Despite its kink-preventing, multiple independent ring design, the Anaconda is associated with the highest occlusion rate (6,4%), potentially as a drawback of its flexibility. A recent master's thesis study of postoperative angulation changes in Anaconda endografts shows an increase in limb curvature (Figure 1, A, solid blue line) over time. We hypothesize that this increased angulation might perturbate blood flow, locally, resulting in a higher occlusion risk. High shear (Figure 1, B) and fluid stasis (Figure 1, C) are in particular known to increase the platelet activation potential (PAP) [2]. PAP is a novel parameter that, together with blood stasis, has been linked to the formation of thrombus that could eventually cause limb occlusion.

Given the current hypothesis, new techniques are needed to visualize blood flow over the full diameter of the Anaconda limb in order to quantify the PAP and areas of fluid stasis. The most widely known in vivo flow measurement technique is ultrasound Doppler (DUPLEX) which, however, only provides flow information within a small sample volume (Figure 1, A, left) [3] and is therefore insufficient to address the present challenge. Furthermore, magnetic resonance (MR) based techniques suffer from severe artifacts generated by the metal stent mesh. In the present study we want to proceed with echo-particle imaging velocimetry (ePIV); a high frame rate (>2000 fps) ultrasound technique to measure the full flow profile. The technique is based on particle tracking, in this case micro bubbles that are injected in the vascular system. Laser PIV is the in vitro gold standard, but requires optical access to the non-transparent endograft. ePIV can be used both in vitro and in vivo, allowing easy transfer from the lab setting to the clinic [4].

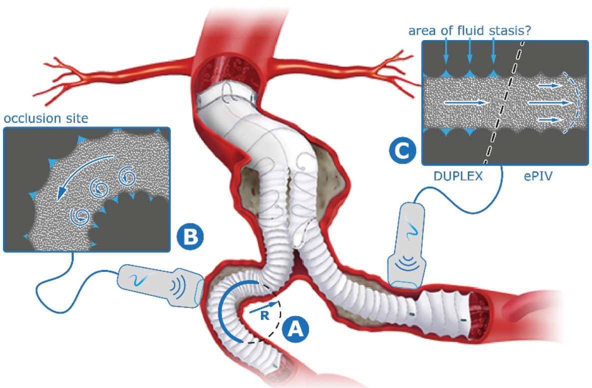

Figure 1: Clinical problem and proposed solution. Vascular anatomy in red, endograft in white.

Goal

The goal of our project is to investigate the expected correlation between blood flow disturbance and limb occlusion. The results could be used to identify patients at risk during follow-up and adapt the instructions for use of the Anaconda endograft.

Assignment

To investigate on the influence of blood flow dynamics on limb occlusions, the student will perform ePIV measurements on a thin-walled AAA phantom in an in-vitro flow setup. Due to the flexibility of the thin-walled AAA phantom, the impact of the following geometrical parameters on the blood flow dynamics will be investigated independently:

- Angle of bifurcation at common iliac arteries.
- Angle of bifurcation at internal and external iliac arteries.
- Aneurysm neck angulation.
- In-plane and out-of-plane positioning of the arteries.
- Tortuosity and curvature.

Based on previous research, it is already known that some of the above-mentioned geometrical parameters could influence limb occlusions [5]; however, relations between these geometrical parameters and possibilities of limb occlusion after EVAR is still not known. Therefore, by performing those measurements, we will investigate on various geometrical cases in a controlled in-vitro condition. Thereafter, by quantifying the flow field using ePIV experiments, we could quantify the impact of each geometrical parameter on developing limb occlusion. Furthermore, the student will be guided to perform Laser PIV experiments over the transparent regions, where the Anaconda endograft is not present, to validate the ePIV measurements.

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