# PATIENT-SPECIFIC ANALYSIS OF THE HAEMODYNAMIC FACTORS CONTRIBUTING TO RESTENOSIS IN PERIPHERAL ARTERIAL DISEASE

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## Introduction

Restenosis is the reoccurrence of stenosis, an abnormal narrowing (≥ 50% [1]) of blood vessels undergoing revascularisation procedures to treat atherosclerosis. Restenosis is linked with different demographic and clinical risk factors [2]. Altered haemodynamic indices also seem to play a role in restenosis progression [3]. Restenosis prediction models in the literature consider predictors in silos, sacrificing essential information contributing to what is, undoubtedly, a multivariable phenomenon. This results in models with limited predictive power. A more holistic approach integrating haemodynamic indices and routinely collected variables into data-driven models may lead to more accurate tools able to classify patients' risk of developing restenosis in a defined time interval. For this, an in-depth understanding of the relevant haemodynamic factors to be included in the models and their contribution to disease progression is needed.

## Methods

High-quality datasets of computed tomography (CT) scans and Doppler ultrasound images of six patients who underwent revascularisation procedures (i.e. stenting or bypass) having heterogeneous follow-up time points were considered. Data were obtained from VA Connecticut Healthcare Systems, West Haven, USA.

The patients' vessel geometries were reconstructed and patient-specific computational fluid dynamics (CFD) analyses were performed following the computational workflow developed by Colombo et al. [4]. An additional step accounting for neointimal hyperplasia (NIH) removal in the reconstruction phase was added to the algorithm. The most commonly reported haemodynamic indices linked to restenosis (i.e. Time-Averaged Wall Shear Stress (TAWSS), Oscillatory Shear Index (OSI), Relative Residence Time (RRT)) as well as the Topological Shear Variation Index (TSVI)) were computed. Their relationship with vessel lumen remodelling was investigated.

## Results

Fig.1 shows TAWSS and RRT 3D haemodynamic maps and indices comparison within follow-ups for a patient of the cohort with an implanted bypass for whom no significant lumen remodelling was observed from baseline to 16-month follow-up. Despite this, the distributions of the haemodynamic indices were all statistically significantly different (Mann-Whitney U test, p-value $\leq 0.05$) within the two considered time points.

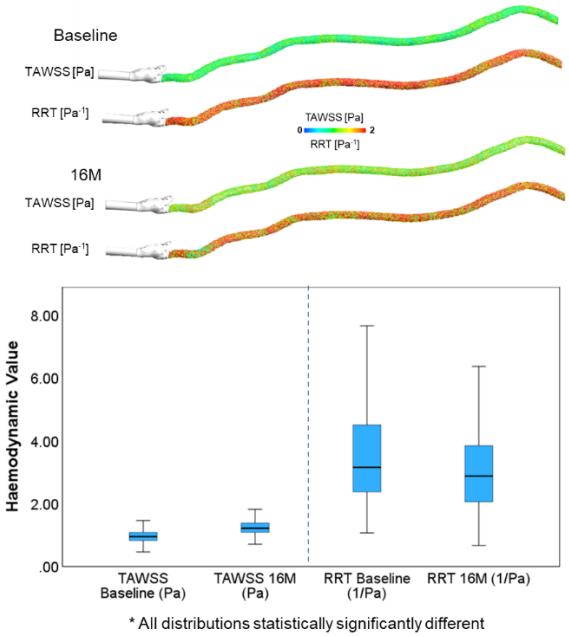


*Figure 1: 3D haemodynamic maps and box plots of TAWSS and RRT distributions comparison at different follow-ups.*

## Discussion

The relationship between vessel lumen remodelling and altered haemodynamic indices within follow-ups is critical to define their contribution towards disease progression. However, even small vessel changes might lead to statistically significantly different haemodynamic indices. This suggests that haemodynamic changes might not result in significant vessel lumen change immediately, but effects might appear in a longer time frame. Analyses performed on the whole dataset will help to better define the relationship between haemodynamics change and vascular remodelling, with the ultimate goal of developing accurate data-driven models for restenosis prediction.

## References

1. Singh et al, Circulation, 109, 2004.
2. Buccheri et al, J of Thoracic Disease, Vol.8, 2016.
3. Gökgöl et al, Biomech Model Mechanobiol, 2019.
4. Colombo et al, Med Eng Phys, 2020.

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