Go With the Flow: The Impact of Stent Geometry on Haemodynamics and Cellular Migration

Luke Boldock[1 2 *], Ana Paula Narata[4], Paul C Evans[2 3], Cecile M Perrault[1 2]

[1]Department of Mechanical Engineering, [2]INSIGNEO Institute for *in silico* Medicine and [3]Department of Infection, Immunity and Cardiovascular Disease, University of Sheffield, UK
[4]INSERM U930, Université François Rabelais de Tours & Hôpital Bretonneau, Tours, France
*Email: mea03lb@sheffield.ac.uk

The Clinical Challenge

Cardiovascular disease is the single biggest cause of death worldwide. Each year, millions of people require cardiac artery stenting, the gold standard treatment for this enormous health burden, to open narrowed arteries or to divert blood away from aneurysms.

However, post-procedure, stent-induced clot formation or re-narrowing of stented arteries impedes recovery and adversely affects quality of life. As life expectancy increases, optimisation of this intervention is vital.

The Bioengineering Approach

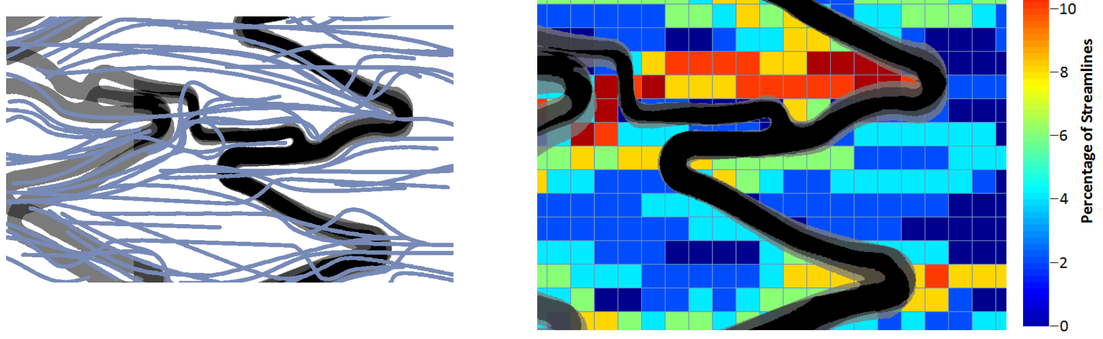
We focus on the mechanical environment of stented arteries. Specifically, the response of endothelial cells (EC) to shear forces generated by flowing blood (haemodynamics). These cells line the inner wall of blood vessels and regrowth of a healthy EC layer is key to optimal patient outcome.

Here, we investigate how stent geometry affects blood flow, how this change influences EC behaviour and how this knowledge will inform stent design.

Modelling the Problem: A Benchtop Blood Vessel

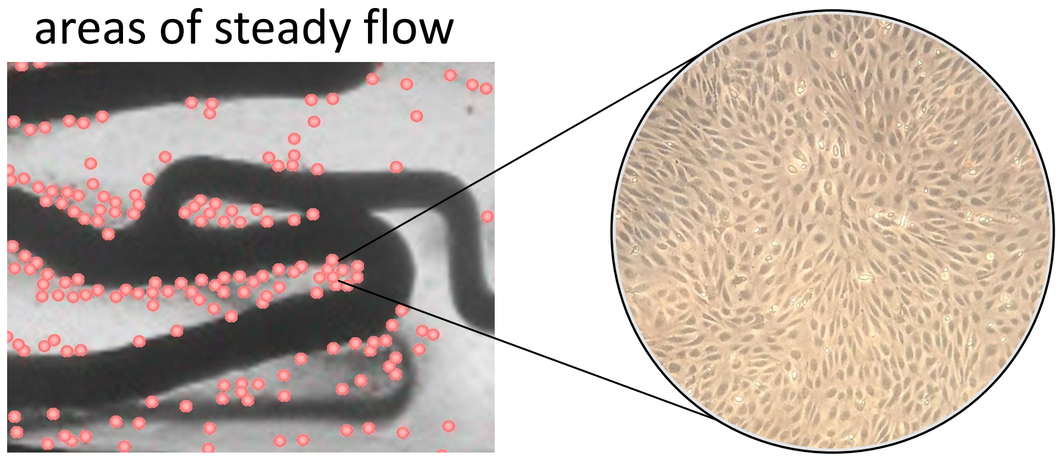
We have created a model vessel to examine stents under physiological conditions and to analyse the local haemodynamics and EC response.

1. Particle tracking emphasises complex flow patterns

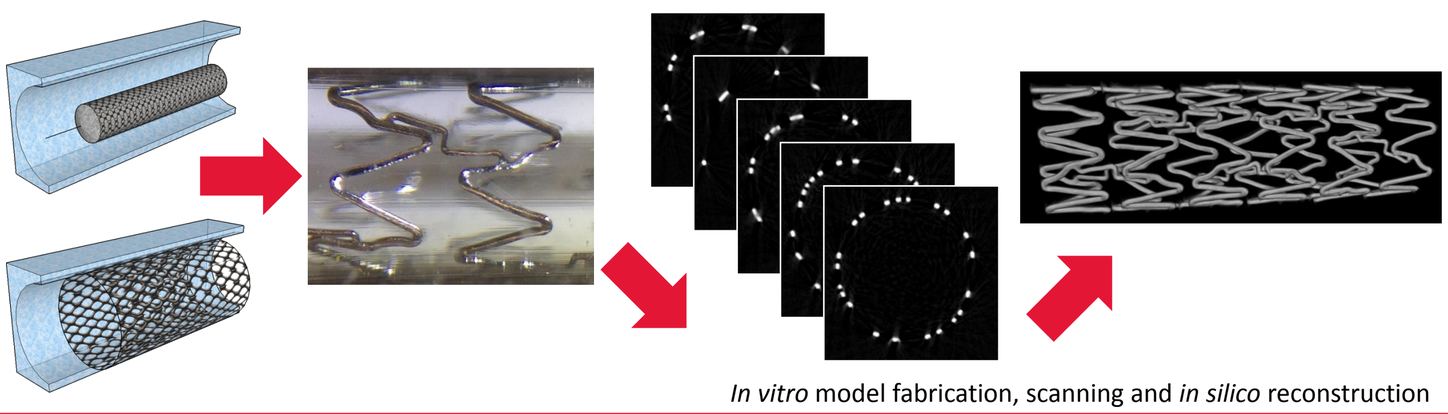


Streamlines and density heat-map of tracked particles

2. Cell tracking reveals preferential EC migration in areas of steady flow

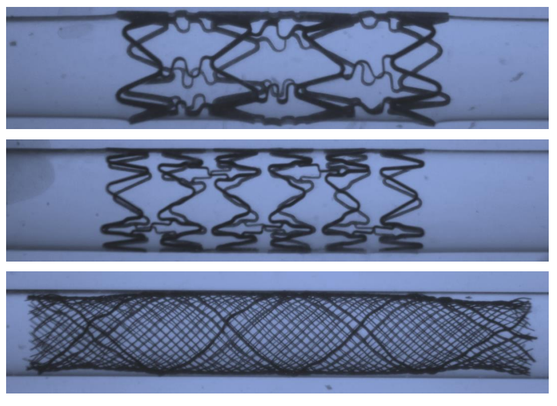


3. CT scan data is used to create high resolution 3D models for in-depth computational fluid dynamics analysis



In vitro model fabrication, scanning and *in silico* reconstruction

4. A range of stents and geometric features were assessed



Conclusions

Stent geometry modifies EC migration, a relationship which can inform future stent design. A thorough understanding of stent haemodynamics and cell migration, using a bioengineering approach, is required to realise this potential.

Acknowledgements

This project is supported by the MultiSim project and the University of Sheffield's 'Engineering for Life', both funded by the Engineering and Physical Sciences Research Council, and by the British Heart Foundation. We thank Professor Julian Gunn for providing coronary stent samples.