Virtual Coronary Stenting: Predictive Treatment Planning in Coronary Artery Disease

Rebecca Gosling1,2, Paul Morris1,2,3, Daniel Silva-Soto1, Patricia Lawford1,2, D.Rodney Hose1,2, Julian Gunn1,2.
1 Department of Infection, Immunity and Cardiovascular Disease, University of Sheffield, UK
2 Insigneo Institute of In-silico medicine, Sheffield, UK
3 Victoria Heart Institute Foundation, Victoria, British Columbia, Canada

Introduction: Fractional flow reserve (FFR)-guided percutaneous coronary intervention (PCI) is associated with improved clinical and economic outcomes compared with angiographic guidance alone (1). A virtual (v)FFR can be calculated, based upon a three-dimensional (3D) reconstruction of the coronary anatomy from the angiogram, using computational fluid dynamics (CFD) modelling (2). This technology can be used to perform ‘virtual’ stenting, with a predicted post-PCI FFR, and the prospect of optimised treatment planning. In this study, we aimed to validate a system capable of predicting the physiological response to a planned PCI procedure based solely upon angiographic images.

Materials and methods: Patients undergoing elective PCI had pressure-wire-based FFR measurement pre- and post- PCI. A 3D reconstruction of the diseased artery was generated from the angiograms and imported into the VIRTUheart™ workflow, without the need for any invasive physiological measurements. VCI was performed using a radius correction tool replicating the dimensions of the stent deployed during PCI. Virtual FFR (vFFR) was calculated pre- and post-VCI using CFD analysis. vFFR pre- and post-VCI were compared with measured (m)FFR pre- and post-PCI respectively.

Results and discussion: 54 patients underwent PCI in 59 vessels. The mean mFFR and vFFR pre-PCI were 0.66 (±0.14) and 0.68 (±0.13) respectively. Pre-PCI vFFR deviated from mFFR by ±0.05 (mean Δ = -0.02, SD= 0.07). The mean mFFR and vFFR post-PCI/VCI were 0.90 (±0.05) and 0.92 (±0.05) respectively. Post-VCI vFFR deviated from post-PCI mFFR by ±0.02 (mean Δ = -0.01, SD=0.03). Mean CFD processing time was 95 s per case. An example case is shown in Figure 1.

![Figure 1](image.png)

Figure 1: A) Coronary angiography revealed a severe mid vessel stenosis in the LAD (arrow). The measured (m)FFR was 0.77. B) The angiograms were used to model the virtual (v)FFR using the VIRTUheart™ system, which was calculated to be 0.75. C) After implantation of a 2.75x18mm stent at the stenosis, the mFFR was 0.88. D) Virtual coronary intervention (VCI) using the VIRTUheart™ system was then used to implant a virtual 2.75mmx18mm stent, and the recalculated vFFR was 0.88.

Translational impact: We have developed a novel VCI tool, based upon the angiogram, that predicts the physiological response to stenting with a high degree of accuracy. This could lead to accurate, patient-specific revascularisation planning.

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References: