Non-Newtonian pulsatile shear stress assessment: a method to differentiate bioresorbable scaffold platforms

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In-vitro and *in-silico* studies have shown that the implantation of coronary stent or scaffold induces changes in local haemodynamic microenvironment. Coronary angiography and optical coherence tomography (OCT) data were used to perform three-dimensional reconstruction of the right coronary of two healthy mini pigs after implantation of a 3.0 × 18 mm Absorb BVS with strut thickness of 157 mm (Abbott Vascular, USA) and 3.0 × 14 mm ArterioSorb with strut thickness of 95 mm (Arterius, UK) (*Figure*). Computational fluid dynamic (CFD) techniques were implemented to simulate pulsatile coronary blood flow. Quemada equation was implemented for shear-thinning blood rheology which integrates haematocrit and shear rate. Endothelial shear stress (ESS) was calculated as the product of local blood viscosity and near-wall velocity gradient. Strut protrusion analysis by OCT was performed using a dedicated software (QCU-CMS v. 16.9, Medis, Leiden, Netherlands).

Endothelial shear stress was quantified around the luminal circumference per 5 degree-interval (sector) and along the axial direction per 0.2mm interval (cross-section). In ArterioSorb (89±7 mm), mean protrusion distance was less than in Absorb BVS (150±9 mm). Thinner struts of ArterioSorb resulted in higher ESS than in Absorb BVS during all coronary flow periods (*Figure*). Endothelial shear stress was higher at the top-of-the struts (red) whereas inter-strut zones demonstrated lower ESS values (dark blue) (Panels B–D). Pulsatile simulation unravelled that at maximal flow, low-ESS areas persisted, that has been shown to promote formation of thrombus and deposition of fibrin (see Supplementary material online, Video S1). In ArterioSorb, 21.6% luminal surface was exposed to low-ESS, whereas in Absorb 47.2% of the vessel surface was subjected to low-ESS.

Pulsatile non-Newtonian ESS permits the assessment of local ESS in different phases of coronary flow. Pulsatile CFD can assess in-vivo the ‘haemocompatibility’ of new coronary bioresorbable platforms.

Supplementary material is available at European Heart Journal online.