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# Increase of coronary microvascular resistances after recanalization with Drug Eluting Stent

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## 1. Introduction

Drug eluting coronary stents (DES) have been demonstrated in the literature to decrease restenosis rate compared to bare-metal stents (BMS). However, the anti-proliferative drugs released by DES may facilitate distal microcirculatory dysfunction, thereby negatively affecting collateral microvessels. Considering the protective effect of well-grown collaterals, in the event of stent thrombosis, impaired collateral function could render the thrombosis much more dangerous (Meier et al., 2007; Togni et al., 2005). Besides, the results of the SYNTAX study indicate that, in patients with complex coronary disease, the need to redo the revascularization is higher when patients have been first treated with DES, as compared to patients who initially undergo coronary artery bypass surgery (CABG) (Kappetein et al., 2011).

In this paper, we present the case of a patient (P) affected by three-vessel coronary disease, previous DES implantation and in-stent restenosis. Using a simulating tool previously developed by our group, we are able for the first time to quantify the impact of the DES eluted drugs on the coronary hydrodynamic parameters of this patient. We compare his results with those obtained for a panel of 10 patients (with three vessel disease, but no stent history) published in Maasrani et al. (2011).

## 2. Methods

### 2.1. Case description

A 65 years old man with no history of myocardial infarction was referred for three-vessel disease. Five years before, he had been treated by percutaneous coronary revascularization (PCI) with deployment of DES within the midportion of the left anterior descending artery (LAD) and within the first obtuse marginal branch of the left circumflex artery (LCx). In mid-2012, the patient developed effort chest pain. Coronary angiography evidenced chronic total occlusion of the first segment of the right coronary artery (RCA), and severe intra-stent restenosis at the level of the left marginal branch, and critical stenosis of the first segment of the LAD. Indication to CABG was posed and use of the off-pump technique was planned.

### 2.2 Clinical measurements

Details about the surgical protocol and the per-operative clinical measurements can be found in Maasrani et al. (2011), and are briefly recalled here. A great saphenous vein graft (SVG) was anastomosed to the right coronary artery, and the pressure distal to the occlusion ( $P_w$ ) as well as the central venous ( $P_v$ ) and aortic pressures ( $P_{ao}$ ) were measured (0G timepoint). After construction of the proximal anastomosis, and with the graft functioning, the flow within the graft ( $Q_{RCAg}$ ), as well as both  $P_v$  and  $P_{ao}$  were measured (1G timepoint). Subsequently, the LAD and LCx branches were revascularized using the two internal mammary arteries. The flow within each mammary graft ( $Q_{LADg}$  and  $Q_{LCxg}$ ) was then measured, with the SVG clamped (2G timepoint), as well as  $P_{ao}$ ,  $P_v$ , and  $P_w$ . The 3G timepoint corresponds to the measurements when the three grafts are functioning:  $P_{ao}$ ,  $P_v$ ,  $Q_{LADg}$ ,  $Q_{LCxg}$ , and  $Q_{RCAg}$ .

### 2.3 Simulating tool

Data were then entered into an analog electrical model of the coronary circulation (Fig.1) aimed at reproducing these clinical situations (Maasrani et al., 2011). In this model, the small diameter vessels like capillaries and collateral vessels are represented only by their resistance:  $R_{LADc}$ ,  $R_{LCxc}$ ,  $R_{RCAc}$ , and  $R_{col}$  (same  $R_{col}$  in all the collateral pathways). They are determined in a patient's specific manner. The input of the model is the aortic pressure wave,  $P_{ao}(t)$ . The Matlab (Simulink) simulations allow to predict flow and pressures in any branch of the model and for all surgical cases (0G, 1G, 2G, 3G). The calculated quantities are time-dependent, but we focus on average cardiac cycle values. The collected clinical data are also average cardiac cycle values.

## 3. Results and Discussion

The values of the capillary and collateral resistances (in mmHg.s/ml) obtained for Patient P are  $R_{LADc} = 241$ ,  $R_{LCxc} = 808$ ,  $R_{RCAc} = 213$ , and  $R_{col} = 2980$ . They can be compared to the mean values obtained for the group of 10 patients studied in Maasrani et al. (2011):  $R_{LADc} = 159 \pm 97$ ,  $R_{LCxc} = 125 \pm 60$ ,  $R_{RCAc} = 125 \pm 88$ , and  $R_{col} = 521 \pm 282$ . All the microvascular resistances of Patient P are higher than those of other patients, and especially

