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A Patient-Specific Computational Study of Right Coronary Artery Flow in Pulmonary Hypertension

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Pulmonary hypertension (PH) is a condition in which mean pulmonary artery (PA) pressure exceeds 25 mmHg. Symptoms include shortness of breath, lethargy and oedema. Approximately 200,000 hospitalisations and at least 15,000 deaths occur due to PH in the United States of America annually [1]. Clinical evaluation is invasive, as it is not possible to measure PA pressure without the use of a pressure wire. Therefore, novel approaches for evaluating PA pressure are required.

Limited studies of right coronary artery (RCA) flow in PH exist in the literature [2]. Because of the close relationship between the pressures in the pulmonary artery and in the right ventricle, and because right ventricular (RV) pressures affect the RCA flow, information regarding PA pressure may be present in the RCA flow profile.

In this work, we study RCA flow in the presence of PH using an image-derived computational haemodynamics model created in the CRIMSON environment [3]. Patient data was obtained from a hybrid cardiac MRI-catherisation study of an infant with isolated post-capillary pulmonary hypertension secondary to congenital aortic stenosis. The major pulmonary, systemic and coronary vessels were segmented from the MRI, creating a geometric model. Lumped parameter network models of the coronary and distal vascular beds, venous system and the heart were employed to create a complete closed-loop circulatory system. Clinical measurements of pressure in the left and right ventricles (LV and RV), main PA (MPA) and aorta, and of RV and LV volumes and MPA flow rates were used to parameterise the baseline model of the patient (Case A). Similar clinical data of two further pharmacological states was used to create two further models. Specifically, one of dobutamine stress (Case B) which increases heart rate and myocardial oxygen demand without affecting systemic vascular resistances, and one of nitric oxide vasodilation (Case C).

In all three cases, we examined RCA flow. We observed that the ratio of peak systolic to peak diastolic flow increased as the mean PA pressure decreased. This ratio may be a good metric of PA pressure, and therefore further investigation of its potential utility is warranted.

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