Proceedings Paper:

Taylor, D., Morris, P.D. orcid.org/0000-0002-3965-121X, Gunn, J. orcid.org/0000-0003-0028-3226 et al. (9 more authors) (2022) Refining Murray’s law in human epicardial coronary arteries. In: Journal of the American College of Cardiology. Elsevier , p. 665.

https://doi.org/10.1016/S0735-1097(22)01656-4

A NOVEL PREDICTIVE MODEL OF CORONARY ARTERIAL INLET, OUTLET AND SIDE-BRANCH BLOOD FLOW

Authors: Daniel Taylor[a], Vignesh Rammohan[a], Ian Halliday[a,c], David R Hose[a,c], Rebecca Gosling[a,b,c], Marcel van 't Veer[d], Pim Tonino[d], Daniëlle Keulards[d], Jeroen Feher[e], Michel Rochette[e], Julian P Gunn[a,b,c], Paul D Morris[a,b,c]

[a] Dept of Infection, Immunity and Cardiovascular Science, University of Sheffield, Sheffield, UK, [b] Dept of Cardiology, Sheffield Teaching Hospitals NHS Foundation Trust, Sheffield, UK, [c] Insigneo Institute for In Silico Medicine, Sheffield, UK, [d] Dept of Cardiology, Catharina Hospital, Eindhoven NL, [e] ANSYS Research and Development, Lyon, Fr.

Background
Ischaemic heart disease causes an insufficiency of coronary blood flow (CBF); but absolute flow (mL/sec) cannot be directly measured, so cardiologists use measures of pressure, Doppler-velocity and thermodilution as proxy markers. Recently, we described a novel computational fluid dynamics (CFD) model of absolute coronary blood flow modelled from angiography, and a standard pressure wire measurement (virtuQ™). The aim of this project was to develop and validate a method for simulating and predicting CBF at all levels of the epicardial circulation.

Methods
Invasive angiograms from 27 patients with chronic coronary syndrome were modelled. Inlet and outlet flows were modelled using virtuQ™. In this newly-developed method, side-branch flow was simulated by implementing a 'porous wall' boundary condition in the CFD model. The magnitude of flow loss was predicted by Murray's vascular scaling law. Side-branch flow was simulated a) homogeneously (diffuse flow along arterial wall) and b) regionally (proportional to the reduction in vessel calibre). Results were validated against the continuous infusion thermodilution (Abbott, Coroventis™) method using the Rayflow catheter (Hexacath).

Results
Both methods were successful but the homogenous method (r=0.47, P 0.0064; zero bias; 95% CI -168 to +168 mL/min) was superior to the regionalised method (r=0.43, P 0.0127; zero bias; 95% CI -175 to +175 mL/min) when compared with the invasive technique.

Conclusions
Absolute coronary blood flow can be estimated from angiographic images and a pressure wire measurement using a computational workflow (virtuQ™). The method includes a model of flow loss from visible and invisible branches. This may be useful in patient-specific coronary physiological modelling and advanced physiological assessment.