REDUCED-ORDER MODELLING FOR CARDIOVASCULAR PROBLEMS

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MINI-SYMPOSIUM PROPOSAL

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Strategies based on reduced-order modelling, generally consisting of one-dimensional (1D) and/or lumped parameter (0D) equations, offer an efficient way to simulate blood flow in vascular networks and interactions between the heart and the vasculature, providing useful insights into the physiological underpinnings of clinical observations. In this context, the analysis of pressure and flow waveforms may provide useful information about arterial mechanical properties. While the basic methodology is well established, there has been an increasing number of different approaches over the last decade, and focus is now shifting to experimental and clinical validation of these models, to quantification of uncertainty and sensitivity analysis, and to possible clinical applications.

This mini-symposium aims to address many of these aspects with a particular emphasis on challenges and translational opportunities of reduced-order modelling. Possible topics include but are not limited to:

- Reduced-order methods for modelling the heart, valves and ventriculo-vascular coupling, modelling of congenital heart disease, modelling of the coronary circulation and mechanisms of myocardium-vessel interactions (*e.g.* with application to estimation of fractional flow reserve–FFR), modelling of the pulmonary circulation (*e.g.* with application to pulmonary hypertension), modelling of the intra/extra cranial venous system (*e.g.* with application to chronic cerebro-spinal venous insufficiency).

- Patient-specific modelling: to what extent is it possible to personalise a model for a given application (*e.g.* aortic flow, coronary circulation, arterio-venous anastomosis, etc.)? Validation and robustness of patient-specific models.

- Models incorporating homeostatic mechanisms (auto-regulatory, baroreflex mechanisms, including orthostatic stresses, etc.) and their use in practical applications.

- Open-loop and closed-loop models; geometrical representation: Pros/cons of increasing model complexity? What are the modelling issues related to termination of open-loop systems (boundary conditions)?

- Coupling the cardiovascular system to other body-fluid systems, notably cerebro-spinal fluid and lymphatics.

- Emerging modelling methods for aiding with decision-making (*e.g.* pulse wave analysis, aneurysm detection, monitoring CO_2 balance during laparoscopic procedures, etc.) or refinement of model-based techniques (such as wave intensity analysis or cardiac output estimation) for obtaining clinically useful information from hæmodynamic measurements.

- Uncertainty quantification and sensitivity analysis for reduced-order modelling.

- Software development for clinical applications.

- Methods for measuring pressure and velocity waveforms *in vivo* or *in vitro* (experiments), novel methods of analysis based on the 1D equations.