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Towards a comprehensive active arterial wall model

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In the last couple of decades several modeling methodologies have been proposed in order to characterise the structural response of the arterial wall. Among these studies, only few of them have focused on the modelling of the active layer of the wall, the media, and its fundamental sub-units, called contractile units[1, 2]. This components is extremely relevant in muscular arteries and arterioles, since it is responsable for the lumen modulation and thus of the blood and nutrients transport. Coccarelli et al.[3] have developed an experimentally-validated multiscale model able to reproduce the structural response of the arterial muscle layer induced by specific drug interventions. This study has allowed to quantify the effects of the biochemical cellular dynamics over the resultant/global tissue behaviour. However such methodology is still far from being comprehensive since it does not account for the regulatory action of endothelial layer, which plays a key role as interface between blood flow and contractile media layer. The way in which the endothelium converts the flow shear stress into a chemical signal towards the media is still not completely understood and needs more clarifications. A complete modelling methodology, supported by experimental evidence, may shed light on the control mechanism of the vascular wall system. With the current study, a strategy for integrating all the wall layers/subsytems within the same computational framework is proposed. The dynamics occurring at cellular level for both endothelium and media are governed by set of ordinary differential equations, whilst the structural mechanics calculations are carried out by means of finite element discretisation. The validation testing is not limited only to the classic isometric ring case, where neither flow nor inertia are considered, but is carried out by employing data obtained from cannulated-perfusion experiments.

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