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Incorporating vessel wall remodeling into 1D cardiovascular network models of pulmonary hypertension

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We develop mathematical models for structural remodeling of the vessel wall in the presence of pulmonary hypertension (PH), a rare but deadly disease. As the disease advances, key portions of the cardiovascular network are known to remodel in a manner that adversely affects blood pressure. Increased blood pressure, in turn, can induce further wall remodeling. The precise manner in which these alterations occur is not well understood and varies with both PH type and severity. We present and discuss mathematical models that incorporate PH-induced remodeling of the vessel wall into 1D fluid-structure models of pulmonary cardiovascular networks. The modeling framework for the vessel wall is based on a Holzapfel-Gasser-Ogden type constitutive law for combined bending, inflation, extension and torsion of a nonlinear elastic tube. Of particular interest is the formulation of new relations between blood pressure and cross-sectional area of the vessel wall that capture alterations with advancing PH.