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A TWO-FAMILY FIBER MODEL OF PULMONARY ARTERIES

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Summary: During pulmonary arterial hypertension (PAH), the pulmonary vasculature undergoes structural remodeling that compromise its normal physiological function. In particular, the pulmonary blood vessels undergo currently untreatable changes and develop lesions that alter their biomechanics and mechanobiology. Structural changes supporting the vessel mechanics are here investigated using a two-fiber model.

Distal right pulmonary artery segments were harvested from male Sprague-Dawley rats four weeks after being treated with monocrotaline to induce PAH. These segments were cannulated and mechanically tested in a tubular biaxial setting where circumferential and axial protocols were executed to simulate near in-vivo conditions. Subsequently, the vessels were imaged under a multiphoton microscope to obtain the image projections of collagen fibers. Fiber orientation distributions were obtained in FIJI from 21 images of the center of the vascular wall. Based on the measured intramural pressure, diameter, and axial length and load from the unloading phase, stress and strain were computed for modeling. Two model parameters from axial data, two from circumferential, and one parameter that covers both were simultaneously minimized via a least-squares method in MATLAB.

The model was able to closely reproduce simultaneously the axial and circumferential stress-stretch data. The orientation of the preferred fiber direction varied about 40 degrees in the population studied. This in turn led to a large variation in optimized model parameter values. To verify if the model predictions are robust, a group of arteries with a similar structural organization will be used to investigate how this influences the vessel mechanics.