Novel strategy to characterize arterial wall properties including residual strains

Cardiovascular Biomechanics

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Novel strategy to characterize arterial wall properties *including* residual strains

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Introduction

It is widely recognized that residual strains in arteries reduce circumferential stress ($\sigma_{\theta\theta}$) gradients across the wall at physiological loading conditions [1,2]. A common method to quantify these residual strains is to describe a stress-free geometry with an *opening angle*, α (fig 1). Major drawbacks of this method are difficulties measuring α and the stress-free segment not being a perfect circular structure, impairing the proper measurement of α.

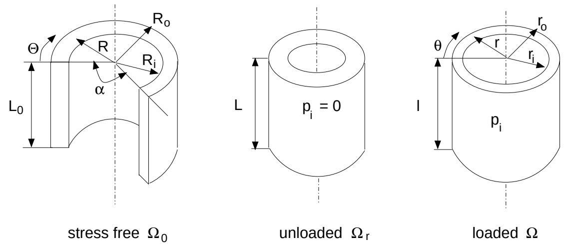

Figure 1: Schematic representation of the opening angle method as a measure for the residual strains

The **aim** of this study is to investigate whether these experimental problems can be circumvented by incorporating the hypothesis of constant $\sigma_{\theta\theta}$ at physiological loading conditions into a strategy to estimate the material properties of the arterial wall.

Methods

The estimation of α is incorporated into a numerical-experimental scheme, designed to estimate the parameters of a 1D, single layer, vascular tissue model [3].

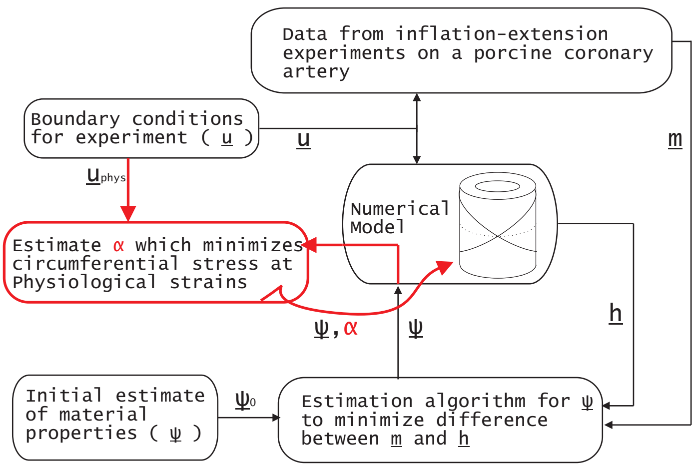

Figure 2: Mixed numerical-experimental method including the estimation procedure for α

Results

A parameter-set was obtained in which the stress gradients are small at physiological loads (fig 3,top,left) *and* which describes the pressure-radius relation of the experiments (bottom,left). A measure for the residual stresses, in the unloaded situation, was found (top,right). Furthermore, α was estimated to be 242° which is close to the value 220° found in the experiment (bottom,right).

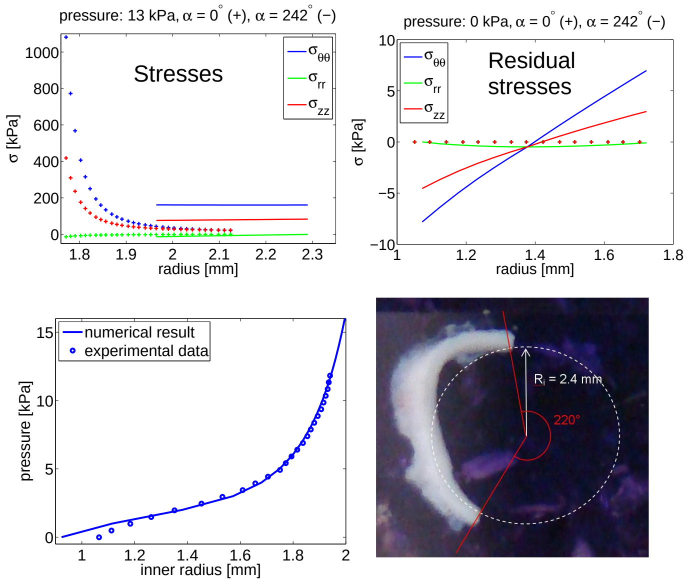

Figure 3: Top: Cauchy stresses with α = 242° (-) and α = 0° (+) at physiological loads (left) and in the unloaded situation (right). Bottom: Pressure-radius relation obtained from the experiments and numerical model (left) and a picture showing the opening angle of the artery (right).

Discussion and conclusions

Although the approach was tested on a single experiment and a relatively simple, 1D, single layer, material model, this study shows the possibility to include a measure for residual stresses by incorporating α, based on the constant $\sigma_{\theta\theta}$ hypothesis, into an estimation scheme. This might replace the need for difficult experimental techniques to characterize residual stresses/strains.

References

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