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Characterizing Large Deformation Behavior of Liver for Surgical Simulation

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Computer-aided medical technologies such as simulators for surgical training, planning, and assessment, are limited by the inability to realistically portray the behavior of the tissues. This work aims to accurately characterize the mechanical behavior of liver under large deformations (>20% nominal strain) typical of surgical manipulation. We first identified the effect of perfusion on mechanical behavior. Creep experiments conducted on porcine livers across four conditions (*in vivo, ex vivo* perfused, *ex vivo* post perfused, and an excised section) suggested that perfusion affects the viscoelastic response, two time constants were needed to characterize the response, and an *ex vivo* perfusion system can nearly approximate the *in vivo* response. A constitutive model based on the combined contributions of individual tissue components was then developed. The model is comprised of three networks working in parallel: a modified 8-chain hyperelastic network represents the elastic response of the tissue's collagenous structure, a nonlinear viscoelastic network represents both the elastic and time response from the parenchyma, and a porous network represents the time response from extracellular fluid flow. Finally, using the perfusion apparatus, indentation tests are performed to identify and validate the model's parameters by solving the inverse problem using an iterative approach. An axisymmetric finite element indentation model has been developed to identify the model's parameters from load/unload experiments, and validated using data from stress relaxation, and creep experiments.