Righetti, Raffaella, "Poroelastography: Ultrasonic Imaging of the Poroelastic Behavior of Phantoms and Tissues"

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Elastography is a well-established imaging modality that utilizes an applied quasi-static compression to estimate and image the mechanical properties of ultrasonically scanned tissues. In the last decade, many studies have been carried out to understand the fundamental tradeoffs in elastographic imaging and to demonstrate the feasibility of generating quality elastograms of tissues *in vitro* and *in vivo*. The majority of these studies were aimed at investigating the mechanical response of tissues to rapid loading under the assumption that the response occurred immediately after the application of the load, so that the tissue could be modeled as a linearly elastic and incompressible solid material. Presently, there still exists a paucity of work on estimating and imaging the Poisson's ratio, compressibility, permeability and time-dependent mechanical behavior of tissues. Due to pathological conditions or simply due to their inherent structure, some hydrated soft tissues are characterized by a high water content that is free to move in the interstitial spaces. These tissues may be modeled as poroelastic materials, and their mechanical behavior is primarily controlled by their elastic and permeability properties. It is expected that an investigation of the spatial and temporal poroelastic behavior of biological tissues could provide a better understanding of their complex mechanical behavior and might be useful for assessing the degree of pathological involvement and monitoring their treatment. The fundamental hypothesis at the basis of the research reported in this dissertation is that it is feasible to use ultrasound elastography to estimate and create quality images of the poroelastic behavior of phantoms and some tissues in unconfined uniaxial compression, which is related to the dynamics of the fluid flow and to the elastic and permeability properties of the materials. This study involved the generation of Poisson's ratio elastograms and poroelastograms from homogeneous and non-homogeneous poroelastic materials in unconfined compression. From the poroelastograms, new types of elastograms, called Poisson's ratio time constant elastograms and permeability elastograms, were generated to obtain information about the underlying permeability distribution of the materials that ostensibly causes the time-dependent changes observed in the poroelastograms. Independent mechanical measurements, simulations, and studies of the major issues related to image quality analysis, such as signal-to-noise ratio, contrast-to-noise ratio, and resolution, were performed and used for designing the poroelastography experiments and interpreting the results. The work reported in this dissertation led to the conclusion that it is feasible to use elastographic techniques to generate quality images of the spatial and temporal poroelastic behavior of certain materials and tissues *in vitro* and *in vivo*.