ULTRASOUND ELASTOGRAPHIC IMAGING OF THERMAL LESIONS AND TEMPERATURE PROFILES DURING RADIOFREQUENCY ABLATION

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Manual palpation to sense variations in tissue stiffness for disease diagnosis has been regularly performed by clinicians for centuries. However, it is generally limited to large and superficial structures and the ability of the physician performing the palpation. Imaging of tissue stiffness or elastic properties via the aid of modern imaging such as ultrasound and magnetic resonance imaging, referred to as *elastography*, enhances the capability for disease diagnosis. In addition, elastography could be used for monitoring tissue response to minimally invasive ablative therapies, which are performed percutaneously to destruct tumors with minimum damage to surrounding tissue. Monitoring tissue temperature during ablation is another approach to estimate tissue damage.

The ultimate goal of this dissertation is to improve the image quality of elastograms and temperature profiles for visualizing thermal lesions during and after ablative therapies. Elastographic imaging of thermal lesions is evaluated by comparison of sizes, shapes, and volumes with the results obtained using gross pathology. Semiautomated segmentation of lesion boundaries on elastograms is also developed. It provides comparable results to those with manual segmentation. Elastograms imaged during radiofrequency ablation *in vitro* show that the impact of gas bubbles during ablation on the ability to delineate the thermal lesion is small.

Two novel methods to reduce noise artifacts in elastograms, and an accurate estimation of displacement vectors are proposed. The first method applies wavelet-denoising algorithms to the displacement estimates. The second method utilizes angular compounding of the elastograms generated using ultrasound signal frames acquired from different insonification angles. These angular frames are also utilized to estimate all tissue displacement vector components in response to a deformation. These enable the generation of

normal and shear strain elastograms and Poisson's ratio elastograms, which provide additional valuable information for disease diagnosis.

Finally, measurements of temperature dependent variables, including sound speed, attenuation coefficient, and thermal expansion in canine liver tissue, are performed. This information is necessary for the estimation of the temperature profile during ablation. A mapping function between the gradient of timeshifts and tissue temperature is calculated using this information and subsequently applied to estimate temperature profiles.