Improved Method and Apparatus for Monitoring Tissue Ablation in Minimally Invasive Tumor Treatment

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Technology description

Elastography is a medical procedure analogous to conventional palpation. It is commonly used to detect tumors and other abnormalities that cause changes in local tissue stiffness. Quasi-static elastography involves analysis of pre- and post-deformation tissue images taken by CT scan, MRI or ultrasound to map stiffness measurements. Dynamic elastography is another method in which vibration is applied to a tissue and the properties of the resulting shear waves are used to deduce quantitative local tissue stiffness values.

The stiffness values or maps produced by elastography also can be utilized to monitor radiofrequency or microwave ablation used to treat tumors. These ablation procedures involve percutaneous insertion of an electrode, which induces ionic heating of the tumor, killing cancerous cells and producing a stiffer necrotic lesion.

UW-Madison researchers previously developed an internal compression technique for monitoring radiofrequency ablation via ultrasonic quasi-static elastography (see WARF reference number P02153US). The ablation electrode described by the researchers includes an ultrasound device to measure local tissue stiffness during compression and monitor lesion progression. The technique allows for accurate three dimensional mapping of tissuesin vivowithout lateral slippage of tissue or organs caused by external compression. This method is greatly beneficial because the physician can verify that the ablated area covers the entire tumor before the procedure is completed. UW-Madison researchers now have developed an ablation electrode that can vibrate ablated tissue and utilize the propagating shear wave velocities to obtain quantitative stiffness measurements. The electrode is used in a new method that improves definition of tissue boundaries and quantization of tissue stiffness by measuring both conventional axial compression and perpendicular shear wave velocity changes. The change in shear wave velocity provides direct measurement of Young’s modulus, the ratio of tensile stress to tensile strain, which may be used to define the stiffness of the treated region.

Specifically, the device for monitoring the progress of ablation comprises an RF or microwave electrode to ablate tissue, an actuator to produce ultrasonic vibration of the RF or microwave electrode, a tissue imager to detect axial displacement data and a computer to receive and analyze displacement data.

The displacement data is used to compute the velocity change in the orthogonal shear wave, which characterizes the ablated lesion. Analysis of the displacement data allows a real-time tissue image to be generated, indicating the size of the ablated and non-ablated regions.

The new electrode displacement imaging method to assist tumor ablation provides accurate quantization of a tissue’s Young’s modulus through an improved computer algorithm that calculates shear wave velocity. Further analysis of discontinuities in the Young’s modulus data enables multidimensional imaging of the tumor and ablated lesion boundaries. The improved technique can be coupled with conventional quasi-static elastography monitoring methods to greatly enhance the quality of elastographic images and quantization of tissue stiffness to assist minimally invasive ablation procedures.
The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing an improved method and apparatus for monitoring radiofrequency electrode ablation via ultrasonic imaging to assist in the minimally invasive ablation of tumors.

Additional Information

DeWall R.J., Varghese T. and Brace C.L. 2012. Visualizing Ex Vivo Radiofrequency and Microwave Ablation Zones Using Electrode Vibration Elastography. Med. Phys. 39, 6692-6700.
DeWall R.J., Varghese T. and Brace C.L. 2012. Visualizing Ex Vivo Radiofrequency and Microwave Ablation Zones Using Electrode Vibration Elastography. Med. Phys. 39, 6692-6700.

For more information about monitoring radiofrequency ablation via quasi-static elastography, see WARF reference number P02153US.
http://www.warf.org/technologies/summary/P02153US.cmsx

DeWall R.J. and Varghese T. 2012. Improving Thermal Ablation Delineation with Electrode Vibration Elastography Using a Bidirectional Wave Propagation Assumption. IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control. 59, 168-173.
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DeWall R.J., Varghese T. and Madsen E.L. 2011. Shear Wave Velocity Imaging Using Transient Electrode Perturbation: Phantom and Ex Vivo Validation. IEEE Transactions on Medical Imaging. 30, 666-678.
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Application area

Enhanced electrode displacement elastography to assist tumor ablation

Quantitative estimation of the Young’ s modulus of tissue

Advantages

Provides quantitative differentiation of tissue stiffness via Young’ s modulus
Accurately delineates tumor and ablation boundaries
Eliminates artifacts present in strain images
Provides real-time imaging and estimation of tissue temperature

Institution

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