Abstract ID: 17274 Title: Ultrasound Symposium

Three-Dimensional Optoacoustic Tomography: preclinical research and clinical applications

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Abstract

We developed a 3D optoacoustic tomography (OAT) system* combining advantages of pulsed optical spectroscopy and high-resolution ultrasonic detection, characterized the system and demonstrated that it produces high-contrast 3D maps of optical absorbance through the large volume of tissue from 20 to 500 mL with resolution better than 0.5 mm. Applications of this technology range from the whole body imaging of a small animal for purposes of preclinical research in oncology to the diagnostic imaging of breast cancer and angiography. An ultrawide-band of ultrasonic frequencies present in optoacoustic signals contains wealth of information, which can be revealed through proper filtering and post-processing. The excellent contrast of hemoglobin and oxyhemoglobin in tissue allows one not only to see the circulatory system, but also to visualize the internal organs. Application of exogenous contrast agents permits imaging of microvasculature of tumors, spine, bones and joints. We demonstrated that either larger anatomy, such as organs or major vessels, or the smaller structures (kidney medullas, ovarian arteries) and even microvasculature can be visualized in case of sufficient contrast depending on methods of signal and image processing.

The most significant value of 3D tomography employing a rigorous solution for the image reconstruction is to provide quantitative information of the absorption coefficient that can be translated into concentrations of tissue chromophores while imaging at several laser wavelengths. This system was employed to generate functional images of blood distribution and molecular images of malignancy-related protein receptors in the cells of cancerous tumors *in vivo*. The most important parameter that enables clinical application is the depth of imaging. We demonstrated that the depth of optoacoustic imaging in tissues exceeds 50 mm for small blood vessel structures. Based on the experimental evidence, translation of the developed preclinical system to clinical applications will be discussed.

* Brecht H-P, Fronheiser M, Su R, Ermilov S, Conjusteau A, Oraevsky AA, Whole-body three dimensional tomography system for preclinical research, *J. Biomed. Optics* 2009; **14**(6), 064007.