Multi-functional Photoacoustic Imaging of Tumor Environment in Thermotherapy

In oncology, thermotherapy is an effective tool against cancers [1]. Randomized clinical studies have proved that thermotherapy, either alone or in combination with radiotherapy and/or chemotherapy, can significantly improve treatment outcomes, including both the response rate and overall survival. To tap the full potential of thermotherapy, it is important to precisely control the temperature in deep tissue during the therapy, both spatially and temporally [1]. It is also important to monitor the hemodynamic and metabolic changes in the tumor environment during thermotherapy. Therefore, an imaging modality that can noninvasively measure the tumor environment, while working with thermal treatment equipment, would greatly benefit thermotherapy. Photoacoustic tomography (PAT), the most sensitivity imaging modality to the rich optical absorption contrast in tissue with high resolution and high speed, is uniquely positioned for this need [2]. Taking advantage of rich optical absorption contrast and weak acoustic scattering, PAT is capable of label-free imaging of a wide range of intrinsic biomolecules with high sensitivity and spatial resolution in deep tissue [3, 4]. This capability enables the measurement of the blood flow and oxygen saturation of hemoglobin by using hemoglobin as the intrinsic contrast [5]. Furthermore, combining the functional, flow dynamic and morphological information, PAT can measure MRO2 at the same time, a parameter that can truly reflect the tissue oxygen metabolism [6, 7]. In addition, using the dependence of PA signal on the tissue temperature, PAT is capable of noninvasive temperature measurement [8]. Due to its natural compatibility with ultrasound imaging, PAT can be seamlessly combined with the therapeutic capability of high-intensity-focused-ultrasound, providing simultaneous cancer treatment and evaluation by a single device. We expect PAT guided thermotherapy will greatly improve treatment outcomes by providing informative feedback according to the tumor environment

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