

Purpose: to demonstrate the feasibility of optoacoustic imaging (OAI) and a signal processing scheme based on singular-value decomposition (SVD) for noninvasively monitoring localized temperature changes during thermal-ablation therapy.

Methods and Materials: A bolus of Indocyanine Green (ICG), which strongly absorbs 800-nm light, was injected in excised chicken and bovine samples using a 26-gauge needle in order to mimic optical absorption in a blood-rich tumor. A wire thermocouple was inserted at the injection site to provide “ground truth” measurement of local temperature. A custom-designed, 1.5-MHz high-intensity focused transducer (HIFU) transducer delivered therapeutic energy in two modes: continuous wave (CW) mode and pulsed mode (80% duty cycle, thermometry performed intermittently during the off periods); and two focal intensities: 1 kW/cm² (cavitation absent) or 4 kW/cm² (cavitation present). The HIFU transducer had a central opening to accommodate a linear, diagnostic imaging probe. The light from a pulsed, 800-nm laser was delivered at the injection site using a bifurcated fiber bundle oriented normal to the imaging plane. The optoacoustic signals emanating from the target site were simultaneously acquired and digitized across the 64 central elements of the imaging array using a fully-programmable research ultrasound engine at a pulse-repetition rate of 10 Hz. SVD analysis of the time-varying OA signals was performed to extract the contributions of temperature change.

Results: The OA amplitude exhibited a direct correlation with change in temperature during heating induced by HIFU and subsequent cooling; this provided adequate means of monitoring temperature changes during pulsed HIFU exposures. Despite the presence of broadband noise associated with inertial cavitation for CW HIFU exposures at high intensity, the SVD analysis was able to extract the local temperature-time profile accurately with root-mean-squared error less than 5°C.

Conclusion: OAI provides a viable, noninvasive method for monitoring local temperature changes in tissue during thermal-ablation therapies.

Funding Support, Disclosures, and Conflict of Interest:

This research was supported by the Bioengineering Research Fund provided by Riverside Research