Photoacoustic imaging of deep targets in the breast using a multi-channel 2D array transducer

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Purpose: To pave the road toward successful application of photoacoustic imaging (PAI) to breast cancer, an initial evaluation of a home fabricated PAI system designed deliberately to achieve high sensitivity for the detection and characterization of vascular anomalies in the breast in the mammographic geometry was completed.

Method and Materials: Signal detection from deep breast was achieved by a broadband 2D PVDF planar array that has a round shape with one side trimmed straight to improve fit near the chest wall. This array has 572 active elements and a -6dB bandwidth of 0.6–1.7 MHz. The low frequency of the array enhances imaging depth and increases the size of vascular collections displayed without edge enhancement. The photoacoustic signals from all the elements go through low noise preamplifiers in the probe that are very close to the array elements for optimized noise control. Driven by 20 independent on-probe signal processing channels, imaging with both high sensitivity and good speed was achieved.

Results: According to our measurements, the end of cable sensitivity was 2.5mV/Pa. Without averaging, the minimum detectable pressure was 80 Pa. Based on the measurements of a point object at different distances from the surface of the array, the lateral resolution of the system ranges from 2.9 mm to 4.2mm and axial resolution ranges from 1.9 mm to 3.7 mm within the distance of 60 mm. To evaluate the imaging depth of this system, artificial vessels embedded deeply in *ex vivo* breasts harvested from fresh cadavers were imaged. Using near-infrared laser light with incident energy density within the ANSI safety limit, imaging depth of up to 49 mm in human breasts was achieved. To validate the multi-modality imaging possibility, PAI images of a compressed breast containing a catheter balloon filled with blood was coregistered with ultrasound images acquired from the same specimen. PAI, based on the intrinsic tissue optical contrast, successfully presented some breast tissue features, including the interfaces on both sides of the skin, the connective tissue sheet in subcutaneous fat, and the lobar capsule.

Conclusions: The current imaging speed of this system is adequate for laboratory research and *in vivo* human studies with small numbers of cooperative volunteers. With a high power tunable laser working on multiple wavelengths, this system might contribute to 3D noninvasive imaging of morphological and physiological tissue features throughout the breast.