

Visualization of breast carcinoma using photoacoustic imaging: the ongoing Twente experience

Michelle Heijblom^{1,2}, Daniele Piras¹, Wenfeng Xia¹, Johan Van Hespem¹, Frank van den Engh², Joost Klaase², Ton van Leeuwen^{1,3}, Wiendelt Steenbergen¹ and Srirang Manohar^{1,*}

¹*Biomedical Photonic Imaging Group, University of Twente, Enschede, The Netherlands*

²*Centre for Breast Care, Medisch Spectrum Twente, Enschede, The Netherlands*

³*Biomedical Engineering and Physics, Academic Medical Center, University of Amsterdam, The Netherlands*

*Presenting author

Purpose:

Worldwide, every year more than 1,300,000 women are diagnosed with breast cancer and annually, about 450,000 women die from the disease [1]. However, the current practice of imaging the breast for the detection and diagnosis of cancer suffers from shortcomings [2]. The interactions of the probe energy—whether X-rays, magnetic field, or ultrasound (US)—with a tumor are not sufficiently specific or sensitive compared with non-pathological tissue. This results in occurrences of false positives and false negatives, which lead to psychological and physical morbidity and mortality. Furthermore, though X-ray mammography is the gold standard imaging modality, X-rays are carcinogenic. Ultrasound and MRI are restricted in their use to being secondary procedures owing to low sensitivity (US), poor specificity (MRI), and high-expense (MRI). There is thus a requirement for a technique that is relatively harmless and has the potential to detect the presence of carcinoma in a manner that is more specific and reliable than inspection of morphologic and anatomic changes.

Methods

Photoacoustic imaging has much potential in detecting the presence of a carcinoma based on the optical absorption contrast manifested by the tumor compared to healthy tissue. This higher absorption is due to the presence of blood contents in the enhanced vascularization associated with the growth and spread of cancer. In PA, short pulses of light are used to illuminate the tissue: absorption induces heating followed by rapid thermal expansion. This generates US waves that propagate through tissue, to be detected by acoustic transducers positioned at the surface. The time-of-flight (TOF), amplitude and duration of acoustic pulses recorded on the tissue surface possess information regarding the location, absorption, and dimensions of the source. By recording signals in a 2-D grid of detector positions, a 3-D reconstruction of the absorber is possible. The advantage of this approach compared with purely optical imaging is that the spatial resolution is superior because of the low scattering experienced by the US during propagation in soft tissue.

In the Biomedical Photonic Imaging Group (BMPI) of the University of Twente (UT) we have worked to develop photoacoustic imaging for breast imaging [3]. In 2007, the BMPI group reported their first results of NIR photoacoustic imaging of breast cancer in human subjects: in 4 of 5 cases of suspect breasts higher photoacoustic contrast associated was observed [4].

Results

In December 2010, a new clinical study has been started at the Centre for Breast Care of the Medisch Spectrum Twente in Oldenzaal. In this study, a number of patients will be measured within a period of 1.5 years. Patients are measured within the normal diagnostic path at the Centre for Mammacare, in between the ultrasound investigation and the ultrasound guided biopsy.

The study can be divided into three phases and for each phase patients are included based on the suspiciousness of their lesion. In the Phase 1 of the study, the focus is on a small number of patients with lesions that are highly suspicious for malignancy. The goal of this part of the study is to optimize the imaging methods for the visualization of malignancies.

At the time of going to press Phase 1 has been successfully completed. Ten technically acceptable measurements have been performed all of breasts highly suspect for malignancy [5]. The photoacoustic images have been compared with conventional imaging methods such as X-ray imaging, ultrasound imaging and in some cases Magnetic Resonance Imaging.

Conclusions

These results confirm the conclusions of the 2007 study: that NIR photoacoustic imaging has potential in the diagnosis of breast cancer. On-going work involves imaging patients in the subsequent phases. In phase 2 of the study, a large number of patients with lesions that are suspicious for malignancy are measured in order to define the photoacoustic markers that are indicative for the presence of a malignancy. In the last phase of the study, the absence of those photoacoustic malignancy markers will be verified in subjects with either healthy breast tissue or benign lesions.

References:

- 1 Tirona, M. T., Sehgal, R. & Ballester, O. Prevention of breast cancer (part I): epidemiology, risk factors, and risk assessment tools. *Cancer Invest* 28, 743-750 (2010).
- 2 Nothacker, M., Duda, V., Hahn, M., Warm, M., Degenhardt, F., Madjar, H., Weinbrenner, S. & Albert, U. S. Early detection of breast cancer: benefits and risks of supplemental breast ultrasound in asymptomatic women with mammographically dense breast tissue. A systematic review. *Bmc Cancer* 9, - (2009).
- 3 Manohar, S., Kharine, A., van Hespén, J. C. G., Steenbergen, W. & van Leeuwen, T. G. The Twente Photoacoustic Mammoscope: system overview and performance. *Physics in Medicine and Biology* 50, 2543-2557 (2005).
- 4 Manohar, S., Vaartjes, S. E., van Hespén, J. C. G., Klaase, J. M., van den Engh, F. M., Steenbergen, W. & van Leeuwen, T. G. Initial results of in vivo non-invasive cancer imaging in the human breast using near-infrared photoacoustics. *Optics Express* 15, 12277-12285 (2007).
- 5 Heijblom, M. *et al* (2011) *in preparation*