Visualization of Breast Carcinoma using Photoacoustic Imaging: The ongoing Twente Experience

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THE TWENTE PHOTOACOUSTIC MAMMOSCOPE (PAM I)
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Aperture to accommodate breast

Light delivery system + scanning system

Ultrasound detector + electronics


1064 nm, 10 ns, 10 Hz pulsed light
  \( < 30 \text{ mJ/cm}^2 \)

1 MHz unfocused US detector array
  - Resolution 4 mm
  - Electronic element scanning
  - 90 averages

55x55 mm\(^2\) region of interest
  - 25 minutes scan duration

Transmission mode imaging
  - Slight breast compression
  - Cranio-Caudal view

Delay and Sum reconstruction

Absorption coefficient \[ \text{mm}^{-1} \]

Wavelength [nm]

Breast tissue (glandular)

Breast tissue (adipose)

\( \text{HbO}_2 \)

\( \text{Hb} \)

Water

Bloodless Dermis

\( 1 \times 10^{-3} \)

0.01

0.1

1

10

100
CASE I (P11-9): Infiltrating Ductal Carcinoma

X-ray mammogram
- Asymmetry in breast appearance (L-R)
- High density region in RCC
- Difficult to pinpoint tumor region and estimate size
- Atypical microcalcifications
- BIRADS 5

Ultrasonogram
- Inhomogeneous mass diameter 30 mm with microcalcifications
- Suggestive for a fibroadenoma
- BIRADS 3
- Second comparable but smaller lesion 8 o'clock

CASE I (P11-9): Infiltrating Ductal Carcinoma

Transverse slice patient 9: distance from surface=17.9 mm

20 mm

42 mm
CASE I (P11-9): Infiltrating Ductal Carcinoma

Magnetic Resonance Image

CASE II (P10-1): Mixed Infiltrating Ductal Lobular Carcinoma

X-ray mammogram
- Asymmetry in breast appearance (L-R)
- Dense area away from the nipple; architectural distortion; suspect microcalcifications – BIRADS 4
- Dense lesion close to nipple – BIRADS 5

Ultrasonogram
- Single lesion inhomogeneous mass near nipple; 18 mm
- Suspect for malignancy – BIRADS 5
- No sign of other atypical masses
**DISCUSSION**

**Discussion:**
- PAM can visualize breast malignancies:
  - with high lesion-to-background contrast – 2x to 5.5x
  - sometimes even in relatively dense breasts
  - at relatively large depths – 33 mm
- Lesion size is slightly underestimated using current thresholding methods

**Outlook:**
- Measure on different types of lesions
- find photoacoustic malignancy markers
- estimate the effect of breast density on performance
- Guide developments towards future generations of PAM

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