Diffuse Optical Imaging of ICG Dynamics in the Diseased Breast with High Temporal Resolution

C. H. Schmitz[1,2], S. Piper[2], P. Schneider[3], N. Volkwein3, N. Schreiter[3], A. Poellinger[3]

[1]NIRx Medizintechnik GmbH, Baumbachstr. 17, 13189 Berlin, Germany;
[2]Charité, Department of Neurology, Charitéplatz 1, 10117 Berlin, Germany; [3]Charité, Department of Radiology, Augustenburger Platz 1, 13353 Berlin, Germany

Introduction

- Contrast-enhanced optical mammography studies utilize the presence of neoangiogenesis in neoplastic tissue, i.e., the formation of new blood vessels that (a) lead to greater local perfusion and (b) are structurally disturbed.
- Local perfusion affects the amplitude of primarily the early components of a dye bolus, and the leakiness of tumor vessels may allow for increased passage of low-molecular weight agents into the interstitial space (extravasation).
- Previously reported contrast-enhanced absorption measurements were able to study some aspects of the breast's perfusion kinetics [1,2]; however, to our knowledge none of these have been performed at scan rates that adequately sample the early bolus dynamics in the tissue.

Aim of our study:
In this report we demonstrate the benefit of high-frame rate absorption tomography of ICG bolus kinetics for localizing breast lesions.

Methods

Number of patients: 20

Inclusion criteria:
- Age > 18 y
- Cup size ~34B
- High probability for breast occupying lesion, BIRADS 4/5
- No operation or biopsy within last 6 months

NIR-Imager:
-DYNOT 232 optical tomography system [3]
(NIRx Medical Technologies LLC, NY, USA)
-31 fiber optic sensors, each withan optical source and a detector
-Sampling Rate: 1.9Hz two complete 3D-datasets/sec
-Data analysis: NIRx NAVI software [4]

Contrast agent:
-25 mg ICG (Pulsion AG, Munich, Germany) in 15 ml saline solution
-High protein binding rate (99% to macromolecules, albumin)
-intravenous injection within ~ 5 sec

Conclusion

- High-frame rate optical imaging is capable of localizing early ICG enhancement following bolus injection and allows differentiation between focal mammographic lesions and healthy breast tissue.
- Our current approach does not provide clear differentiation between benign and malignant lesions.
- Absorption changes during the late measurement phase (>10min) are not efficient to measure an ICG enhancement as a marker for extravasation.

Results

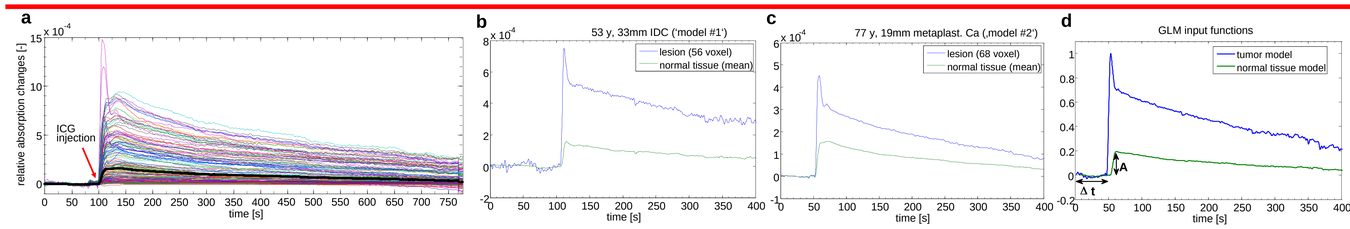

Figure 1. GLM - model synthesis: (a) Reconstructed absorption changes per voxel for a representative subject (77 y, 19mm metaplastic CA) . Only 200 out of 2243 voxel time courses are displayed. The fat black curve represents the average over all voxels. (b,c) ICG absorption changes for tumor area (blue) and normal background (green) as measured in two Ca patients. (d) GLM input functions of tumor and normal tissue, as derived from (b,c). Amplitude A and latency Δt are individually adjusted to the average response of each patient before starting GLM analysis.

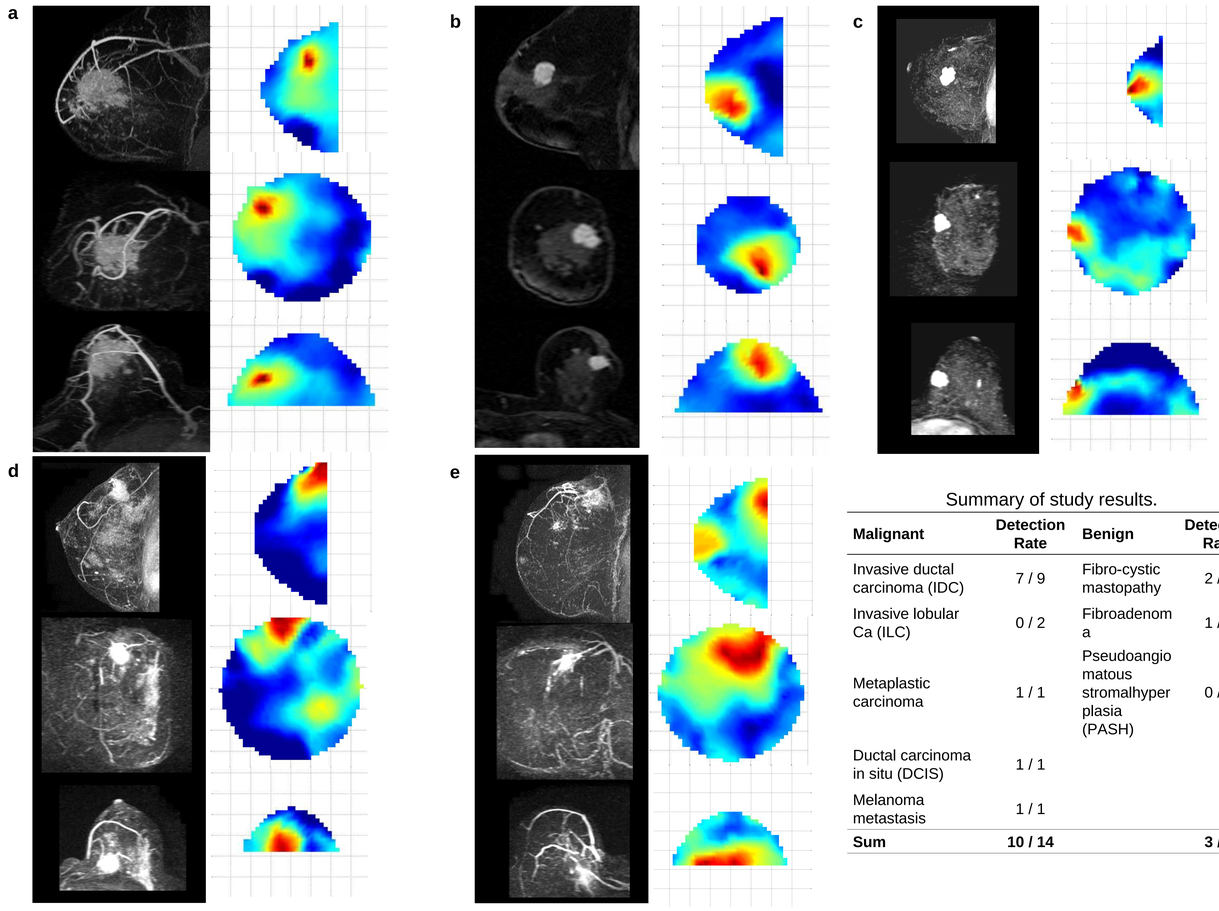

Figure 2. Representative results from five patients. All panels: Top to bottom: mediolateral, coronal, craniocaudal sections; left:MR, right: DOT – beta values for the tumor model function. (a) 53 y, 33-mm IDC (model #1); (b) 77 y, 19-mm metaplastic CA (model #2); (c) 27 y, 22-mm fibroadenoma; (d) 37 y, 22-mm IDC; (e) 68 y, 16-mm IDC.

Summary of study results.

Malignant	Detection Rate	Benign	Detection Rate
Invasive ductal carcinoma (IDC)	7 / 9	Fibro-cystic mastopathy	2 / 3
Invasive lobular Ca (ILC)	0 / 2	Fibroadenoma	1 / 2
Metaplastic carcinoma	1 / 1	Pseudoangiomatous stromalhyperplasia (PASH)	0 / 1
Ductal carcinoma in situ (DCIS)	1 / 1		
Melanoma metastasis	1 / 1		
Sum	**10 / 14**		**3 / 6**

References

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Abbreviations

DOT – Diffuse Optical Imaging
GLM – General Linear Model

cschmitz@nirx.de