UC Irvine

UC Irvine Previously Published Works

Title

Functional diffuse optical spectroscopy of human breast tissue

Permalink

<https://escholarship.org/uc/item/08d6t007>

Authors

Tromberg, BJ
Cerussi, AE
Jakubowski, D
[et al.](#)

Publication Date

2001

DOI

10.1109/LEOS.2001.969273

Copyright Information

This work is made available under the terms of a Creative Commons Attribution License, available at <https://creativecommons.org/licenses/by/4.0/>

Peer reviewed

Functional Diffuse Optical Spectroscopy of Human Breast Tissue

B. J. Tromberg¹, A. E. Cerussi¹, D. Jakubowski¹, N. Shah¹, F. Bevilacqua¹, A. J. Berger⁴, J. Butler², R. F. Holcombe³

¹Laser Microbeam and Medical Program, Beckman Laser Institute and Medical Clinic, University of California, Irvine;

²Department of General Surgery, University of California, Irvine Medical Center;

³Division of Hematology/Oncology, University of California, Irvine

⁴Institute of Optics, University of Rochester

Short Abstract

We describe a method for obtaining broad wavelength (650 nm-1000nm) quantitative optical property data with deep tissue penetration. The wavelength-dependence of absorption (μ_a) and scattering (μ_s') parameters is used to provide fundamental information on tissue biochemistry and structure.

Long Abstract

The use of reflectance spectroscopy to quantitatively characterize cm-thick biological tissues requires the ability to separate the effects of light absorption from scattering. Fundamentally, this can be accomplished by spatially-resolved steady-state, time-domain, or frequency-domain reflectance methods. However, practical considerations limit the applicability of each technique. For use in clinical breast examinations, for instance, the ideal system should acquire data rapidly, probe tissue deeply, and resolve the four major optical components of breast (oxy- and deoxy-hemoglobin, water, and fat) robustly (Figure 1). To ensure accurate predictions, this last requirement suggests the monitoring of as many wavelengths as possible.

Figure 1. Principal component spectra of breast tissue in NIR (from ref 1).

Figure 2. Combined steady state/Frequency domain system (from ref 3).

In this presentation, we describe a method for using steady-state (SS) and frequency-domain (FD) reflectance measurements in tandem to obtain broad wavelength (650 nm-1000nm) quantitative data with deep tissue penetration. The wavelength-dependence of absorption (μ_a) and scattering (μ_s') parameters are used to provide fundamental information on tissue biochemistry and structure. Preliminary clinical results using this technique demonstrate that diffuse optical spectroscopy and imaging can be used to quantify differences between pre- and post-menopausal breast tissue, and normal vs. tumor sites (Figures 3,4). We further show that total hemoglobin content, water, and lipid percentage can be measured quantitatively and these constituents vary with age, tumor type and menopausal status. Because of its unique sensitivity to hormone-dependent alterations, functional characterization using optical methods may provide important insight into physiologic changes accompanying breast disease as well as biologic processes associated with disease risk.

Figure 3. Absorption spectrum of malignant tumor vs. normal breast in post-menopausal subject.

Figure 4. Scattering spectrum of malignant tumor vs. normal breast in post-menopausal subject.

References:

- 1) Tromberg, BJ., Shah, N., Lanning, R., Cerussi, A., Espinoza, J., Pham, T., Svaasand, L., Butler, J. *Non-Invasive In Vivo Characterization of Breast Tumors Using Photon Migration Spectroscopy*. Neoplasia, 2, 1-15, (2000).
- 2) Pham, TH., Coquoz, O., Fishkin, JB., Anderson, E., Tromberg, BJ., *A Broad Bandwidth Frequency Domain Instrument for Quantitative Tissue Optical Spectroscopy*. Review of Scientific Instruments, 71, 1 – 14, (2000)
- 3) Bevilacqua, F., Berger, AJ., Cerussi, AE., Jakubowski, D., Tromberg, BJ. *Broadband Absorption Spectroscopy in Turbid Media by Combined Frequency-Domain and Steady-State Methods*. Applied Optics, 39, 6498-6507, 2000.
- 4) Cerussi, AE., Berger, AJ., Bevilacqua, F., Shah, N., Jakubowski, D., Butler, J., Holcombe, RF., Tromberg, BJ. *Sources of Absorption and Scattering Contrast for Near-Infrared Optical Mammography*. Academic Radiology, 8, 211 – 218, 2001.
- 5) Shah, N., Cerussi, A., Eker, C., Espinoza, J., Butler, J., Fishkin, J., Hornung, R., Tromberg, B. *Non-Invasive Functional Optical Spectroscopy of Human Breast Tissue*. . Proceedings of the National Academy of Science, 98, 4420-4425, 2001.

Acknowledgements

This work was supported by the National Institutes of Health (NIH) Laser Microbeam and Medical Program (#RR-01192), NIH (#GM-50958), the Department of Energy (DOE #DE-FG03-91ER61227), and the Avon Breast Center in the Chao Comprehensive Cancer Center (NCI). A.E.C. acknowledges support from the U. S. Army Medical Research and Material Command (DAMD17-98-1-8186). The authors also acknowledge fellowships from the George E. Hewitt Foundation (AJB) and the Swiss National Science Foundation (FB).