

Diffuse Optical Spectroscopy & Tomography: Fetal hypoxia and Breast cancer ROC curve

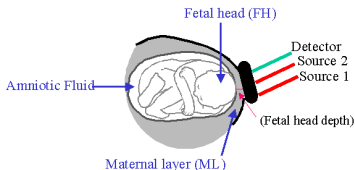
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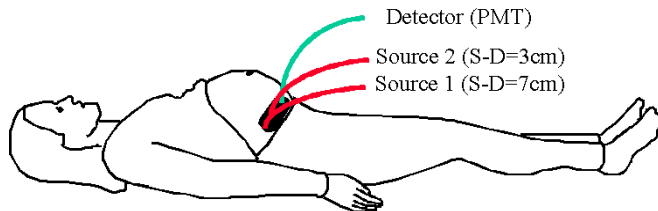
June 4, 2011

Detection of Fetal Hypoxia

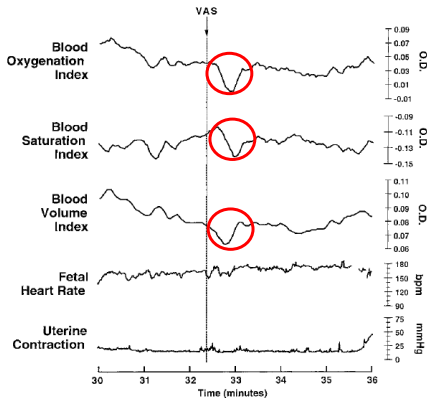


- **Fetal hypoxia** *in utero*
→ Brain damage
- Need: Non-invasive, direct **oxygenation** monitoring device

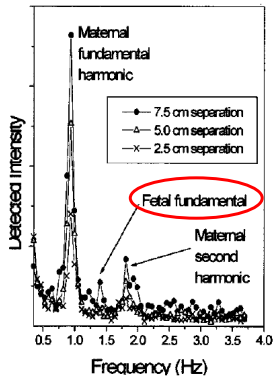
- 1 Can we detect fetal signal?
(e.g. Maternal layer thickness: 1 - 4 cm)
- 2 Can we quantify fetal oxygenation accurately?
(i.e. Separation of maternal and fetal signals)
- 3 Clinical translation?



(1) Signal from Fetus (Human)



N. Ramanujam et al,
J. Maternal-Fetal Medicine (1999)

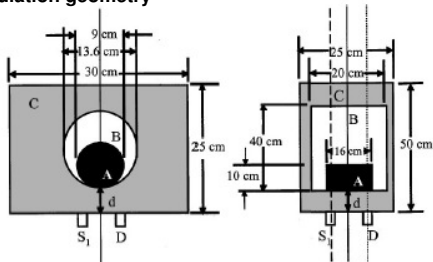


A. Zourabian et al,
J. Biomedical Optics (2000)

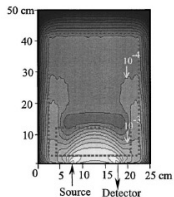
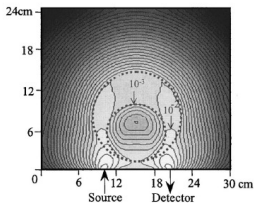
- N. Ramanujam et al., *J. Maternal-Fetal Medicine*, **8**:275-288 (1999)
- N. Ramanujam et al., *J. Biomed. Opt.*, **5**(2), 173-184 (2000)
- A. Zourabian et al., *J. Biomed. Opt.*, **5**(4), 391-405 (2000)

(1) Can we detect fetal signal? (Simulation)

Simulation geometry



Visiting Probability Map



G. Vishnoi et al

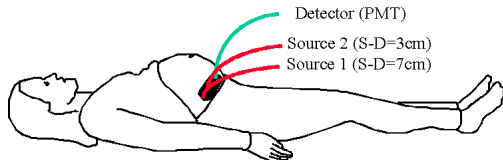
Yes, we can!

(Late gestation model)

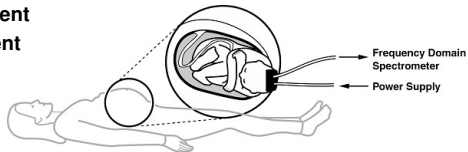
- G. Vishnoi et al., *J. Biomed. Opt.*, **5**(2), 163-172 (2000)
- N. Ramanujam et al., *J. Biomed. Opt.*, **5**(2), 173-184 (2000)
- S. L. Jacques et al., *J. Biomed. Opt.*, **5**(3), 277-282 (2000)

(2) Oxygenation Quantification? (Clinical)

Transabdominal Measurement



Fetal brain measurement before cord detachment

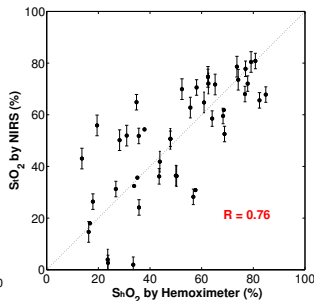
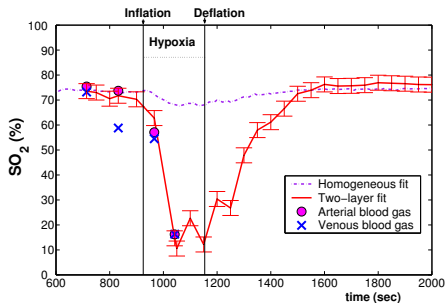
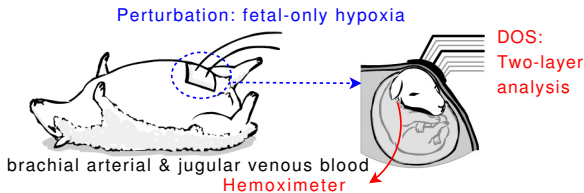
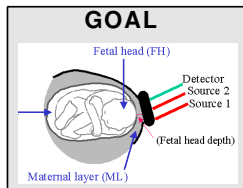


Neonatal brain measurement



Illustrations by Mary Leonard

(2) Accurate Quantification (Animal)



- R. Choe *et al.*, *Proc. Natl. Acad. Sci. USA*, **100**(22): 12950–12954, (2003)
- T. Mawn *et al.*, *J. Biomed. Opt.*, **10**(6), 064001 (2005)
- S. Nioka *et al.*, *J. Maternal-Fetal & Neonatal Medicine*, **17**(6), 393-399 (2005)

(3) Clinical validation/translation?

- 1 Quantification of fetal oxygen status: healthy fetus
 - A. M. Vintzileos *et al.*, *A. J. Obstet. Gynecol.*, **192**, 129-133 (2005)
 - Comparison with trans-vaginal pulse oximeter
 - More data to establish healthy baseline oxygenation
- 2 Refined C-section protocol with better timing and portable instrumentation
- 3 Monitoring before, during, after fetal surgery
(Access to fetus *in distress*)

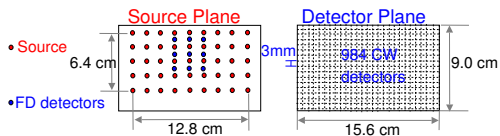
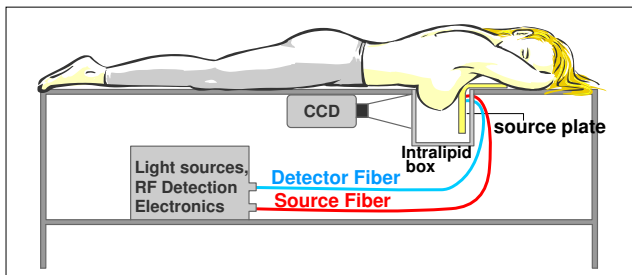
ROC curve

Correspondance between BC & Turgut (2005)

BC: *"Dear Turgut & Arjun,
Strongly suggest you publish where radiologists will read. This is
what Tromberg NTROI needs, some positive results. How about a
ROC curve?"*

Turgut: *"...No ROC curves yet, with five patients, I think all I can
do is to visit RoC (Republic of Cyprus)..."*

Parallel-Plane Diffuse Optical Tomography



Light sources

- 45 sources
- 690, 750, 786, 830 nm
- 650, 905 nm

Detectors

- CCD CW Transmission
- 9 FD Remission

Other features

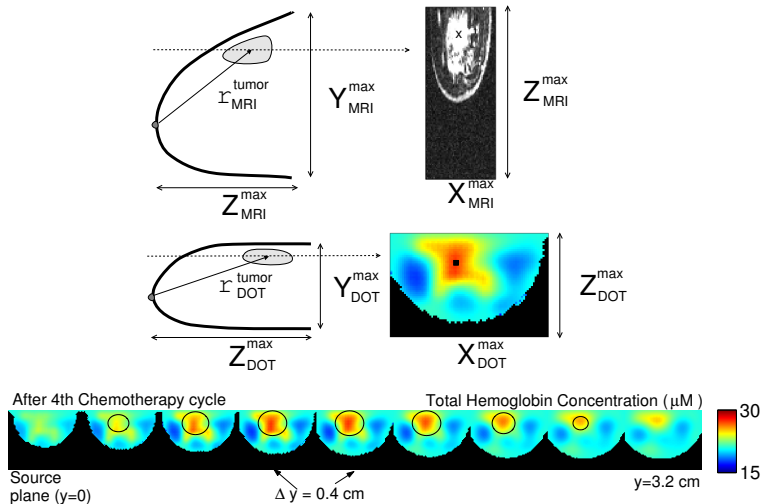
- matching fluid
- soft compression

Data set : 45 x 984 x 6 ~ 266,000

Acquisition time = 8 minutes

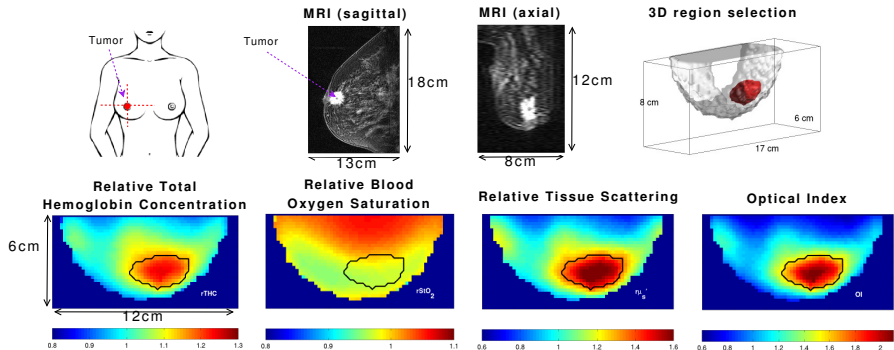
J. P. Culver *et. al.*, *Medical Physics*, **30**, p.235-247 (2003)

Validation with MRI



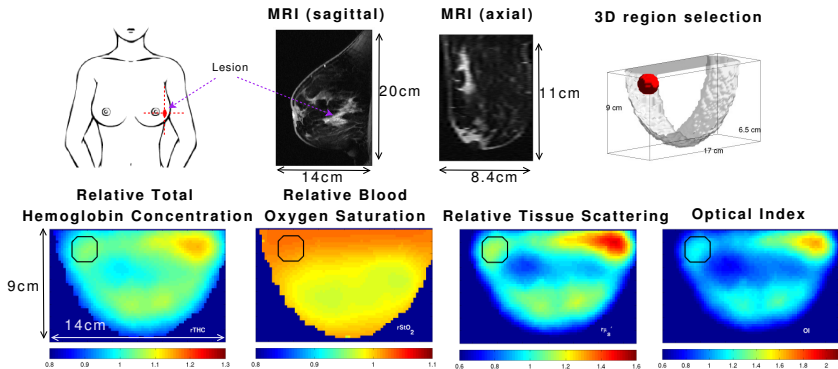
R. Choe *et al.*, *Med. Phys.*, **32** p.1128-1139, (2005)

Example: Malignant Lesion



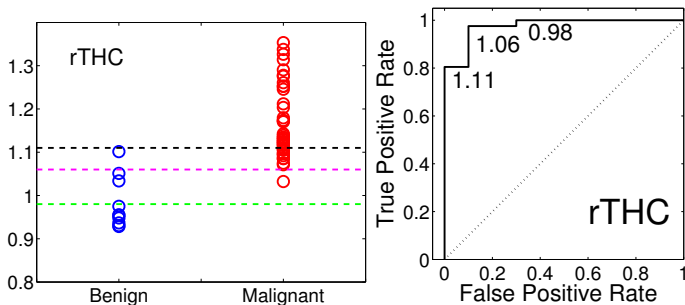
- Relative Total Hemoglobin Concentration (rTHC)
- Relative Blood Oxygen Saturation (rStO₂)
- Relative Tissue Scattering (rμ'_s)
- Optical Index = $\frac{rTHC \cdot r\mu'_s}{rStO_2}$

Example: Benign Lesion



- Fibroadenoma
- Characterization with MRI

Lesion Differentiation (N=51)



- Receiver operating characteristic (ROC) curve
- Area under ROC curves:
 $r\text{THC}, r\text{HbO}_2, r\mu'_s, \text{OI} > 0.9$

R. Choe *et al.*, *Journal of Biomedical Optics* **14**(2), (2009)

- 1 ROC for **Therapy monitoring**: multi-parameter, portable instrumentation
- 2 ROC for **Diagnosis/Characterization**: multi-modality imaging approach
- 3 ROC for **Early detection**: absorption/fluorescence contrast enhanced imaging

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Fetal Hypoxia Project

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