Non-invasive optical measurements of free and bound oxygen in humans

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Intensive Care Medicine unites with Physics and Engineering

My research field

Optical spectroscopy

Broad-band

Near-infrared spectroscopy
Continuous-wave and time-resolved

Tissue oxygenation
(bound oxygen)

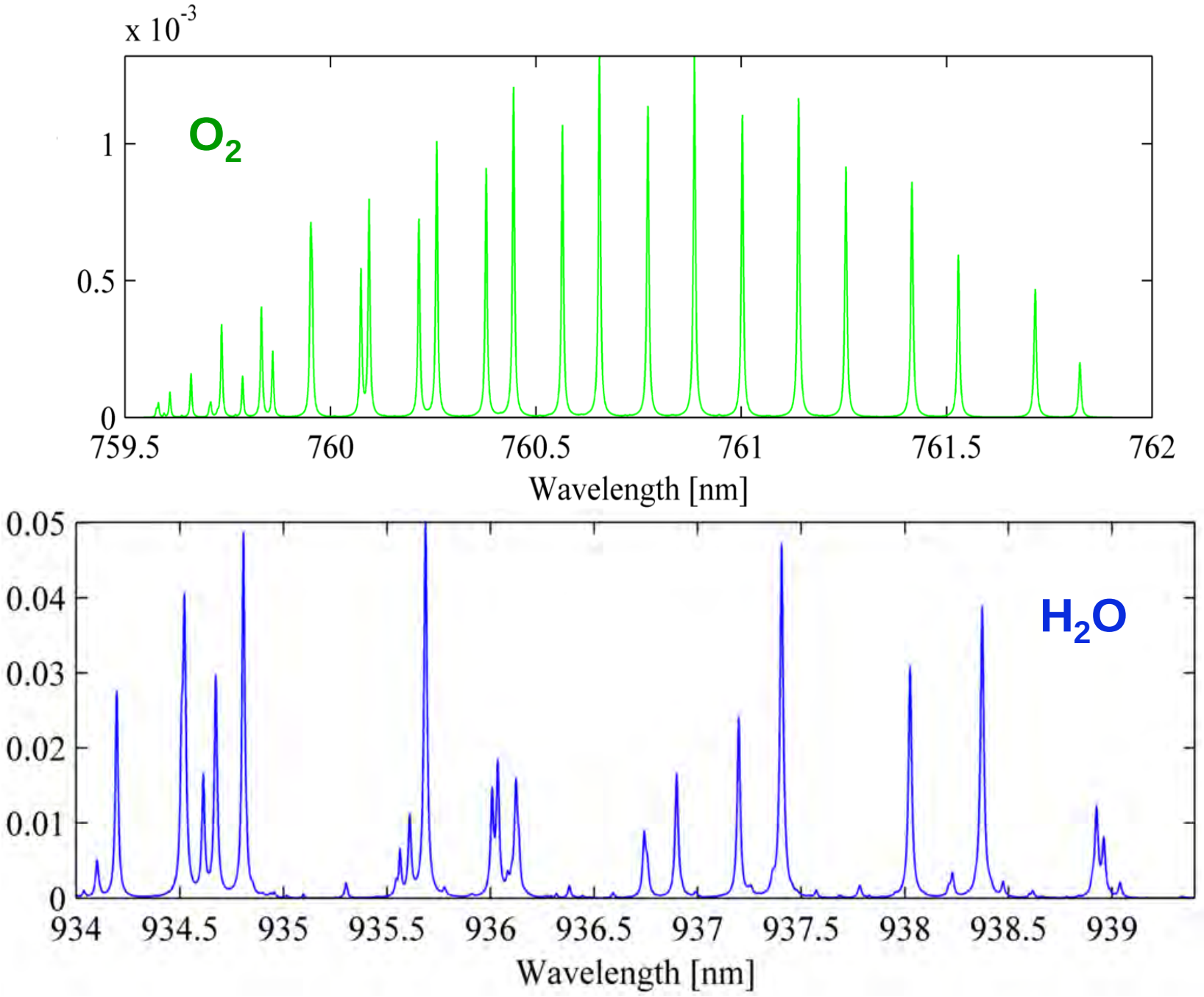
Early detection of
severe critical illness

Narrow-band

Gas in Scattering Media
Absorption Spectroscopy
(GASMAS)

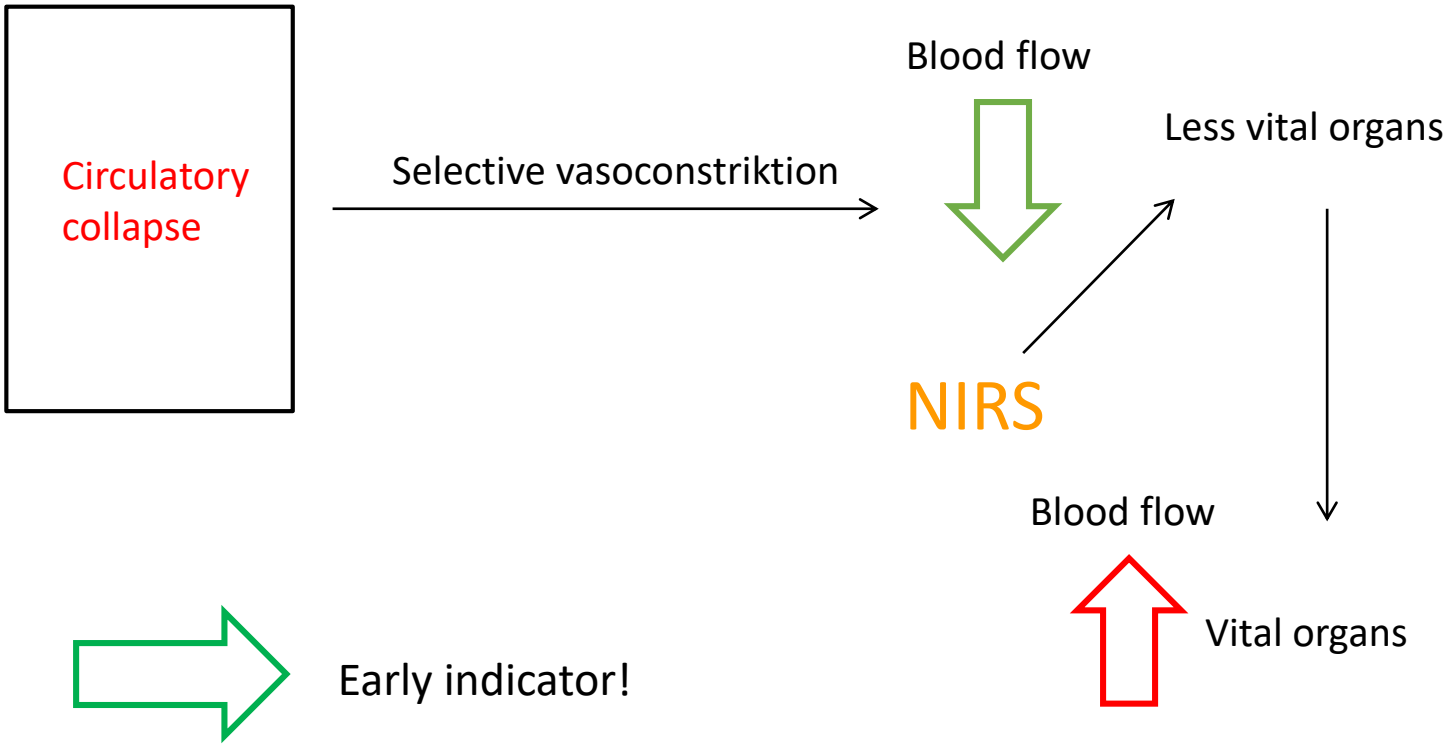
Oxygen and water vapor detection
(free oxygen gas)

Lung monitoring
in critically ill infants


x 10^-3
O2
1
0.5
0
759.5
760
760.5
761
761.5
762
Wavelength [nm]
0.05
0.04
0.03
0.02
0.01
0
H2O
934
934.5
935
935.5
936
936.5
937
937.5
938
938.5
939
Wavelength [nm]

Tissue oxygenation

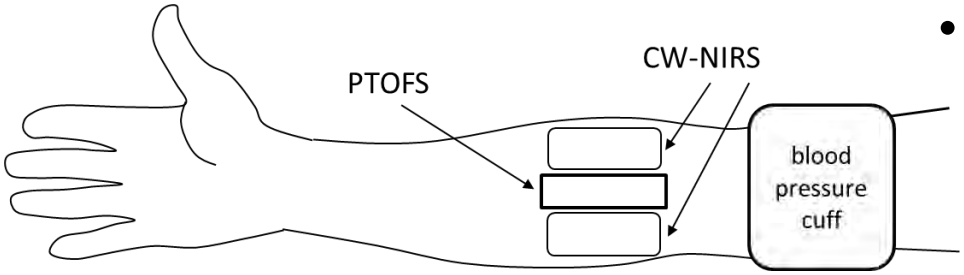
Normal function of the microcirculation is a prerequisite for adequate tissue oxygenation!



CW-NIRS vs pTOFS

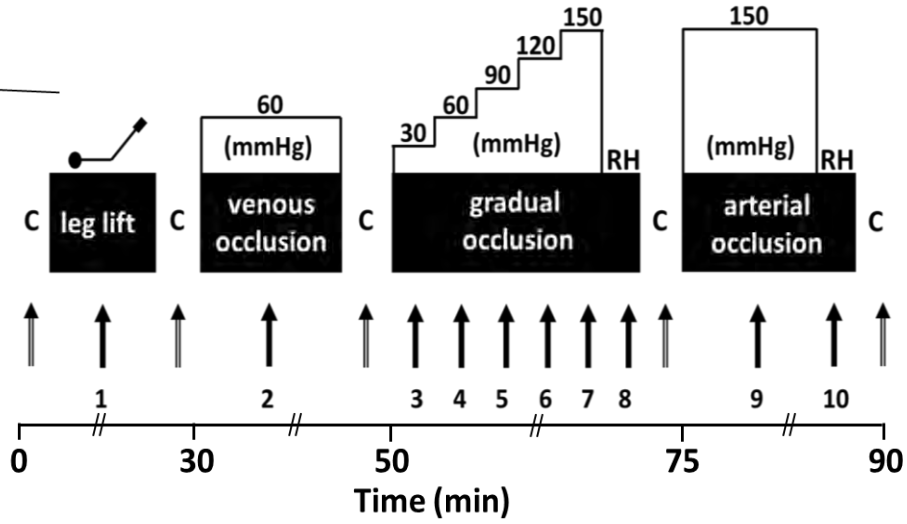
Comparing continuous wave (CW) and time-resolved (pTOFS) near-infrared spectroscopy

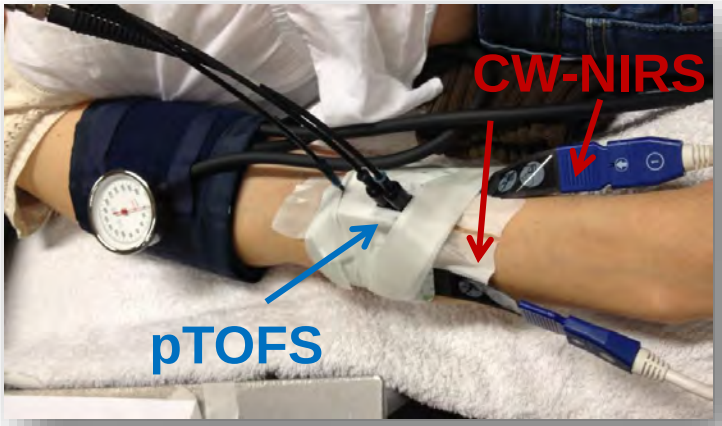
- Healthy volunteers
  - Forearm muscles



Physiological provocations

- Leg lift
- Venous occlusion
- Gradual venous to arterial occlusion
- Instant arterial occlusion





Krite Svanberg E. et al. Time-resolved versus continuous-wave near-infrared spectroscopy for determination of oxygen saturation in human skeletal muscle tissue (Manuscript)

Results

- pTOFS was able to, more readily than the CW-NIRS, record changes in muscle tissue oxygen saturation under various physiological condition
- pTOFS provided values on muscle tissue oxygen saturation with less inter-individual variation
- pTOFS is largely insensitive to skin content of melanin

Lung monitoring

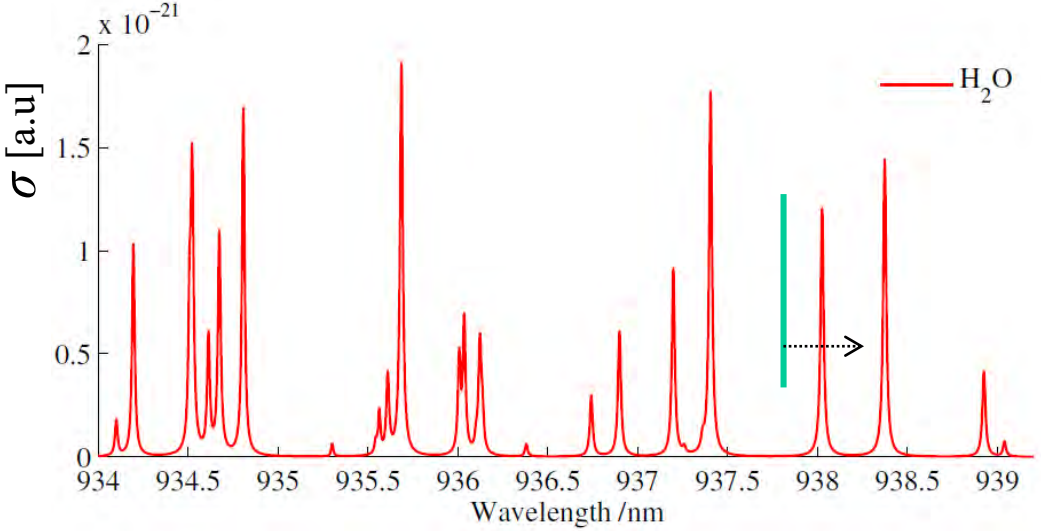
Respiratory Distress Syndrome (RDS)

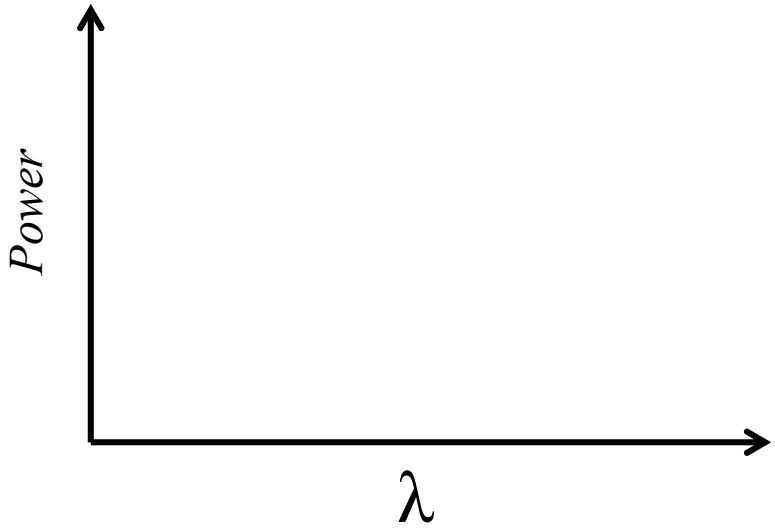
Pulmonary x-ray…

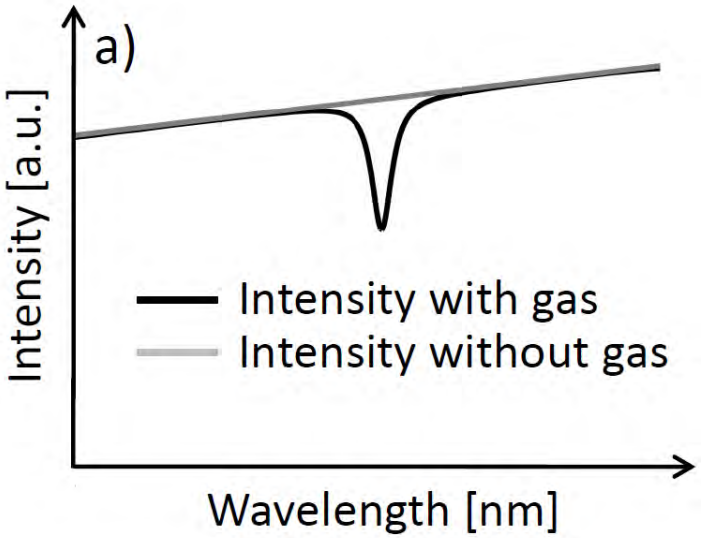
Can the use be reduced?

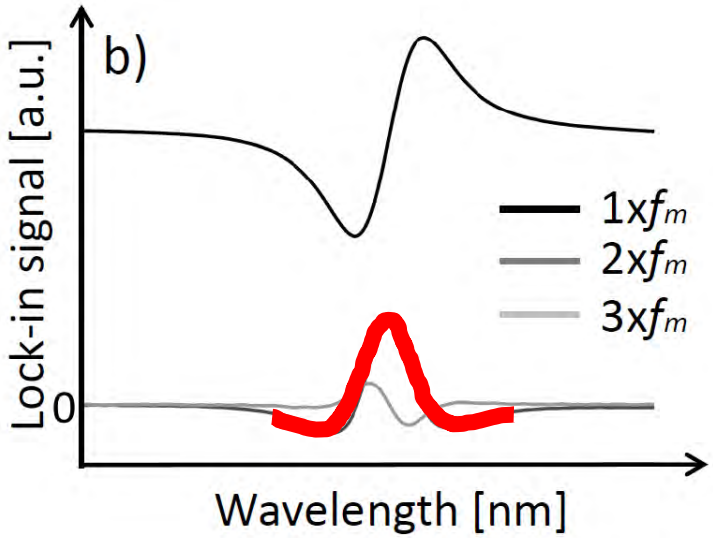
GASMAS

GASMAS


x 10^-21
σ [a.u]
H2O
Wavelength /nm


Power
λ


a)
Intensity [a.u.]
Intensity with gas
Intensity without gas
Wavelength [nm]


b)
Lock-in signal [a.u.]
1xfm
2xfm
3xfm
0
Wavelength [nm]

Development of a new non-invasive continuous surveillance technique for lung function in premature/full-term infants

- **Early phantom measurements (wild boar lung)**

  Lewander M. et al. Non-intrusive Gas Monitoring in Neonatal Lungs Using Diode Laser Spectroscopy: Feasibility Study, J. Biomed. Opt. 16, 127002 (2011), DOI:10.1117/1.

- **Pilot study**

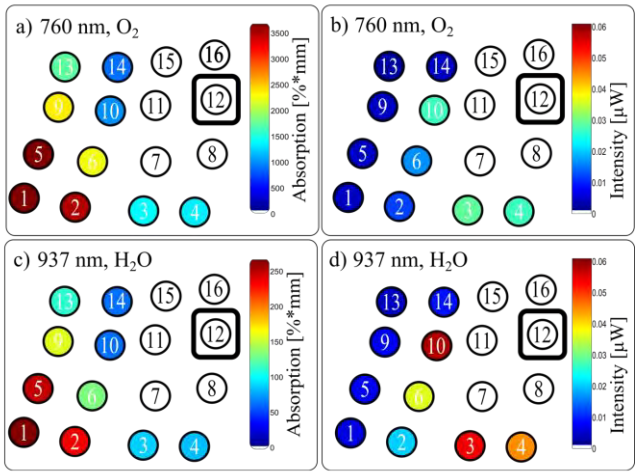
  Lundin P et al.
  J. Biomed Opt. 16 (12), 127005 (2013)

- **Full-term infants**

  Krite Svanberg E et al.
  Pediatric Research 79, 621-628 (2016)

Phantom measurements

1.



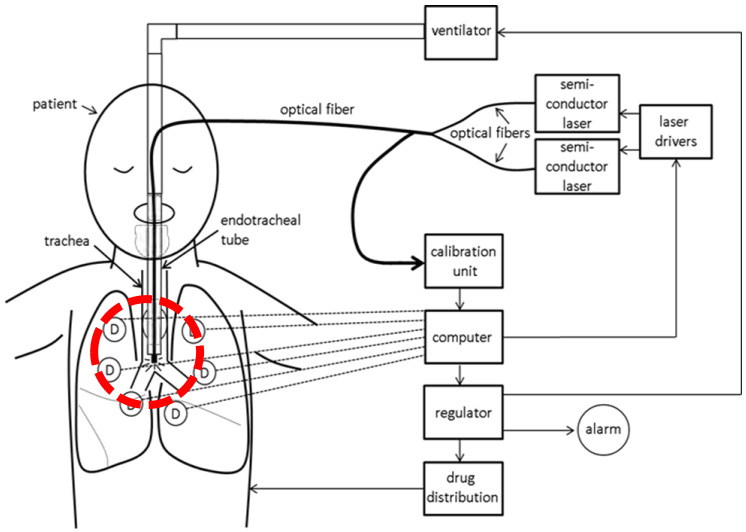
H_2O 937 nm

Measurement geometries

Absorption vs intensity

Larsson J. et al. J. BioPhotonics (2017)
doi.org/10.1002/jbio.201700097

2.



H_2O 820 nm

Internal vs dermal

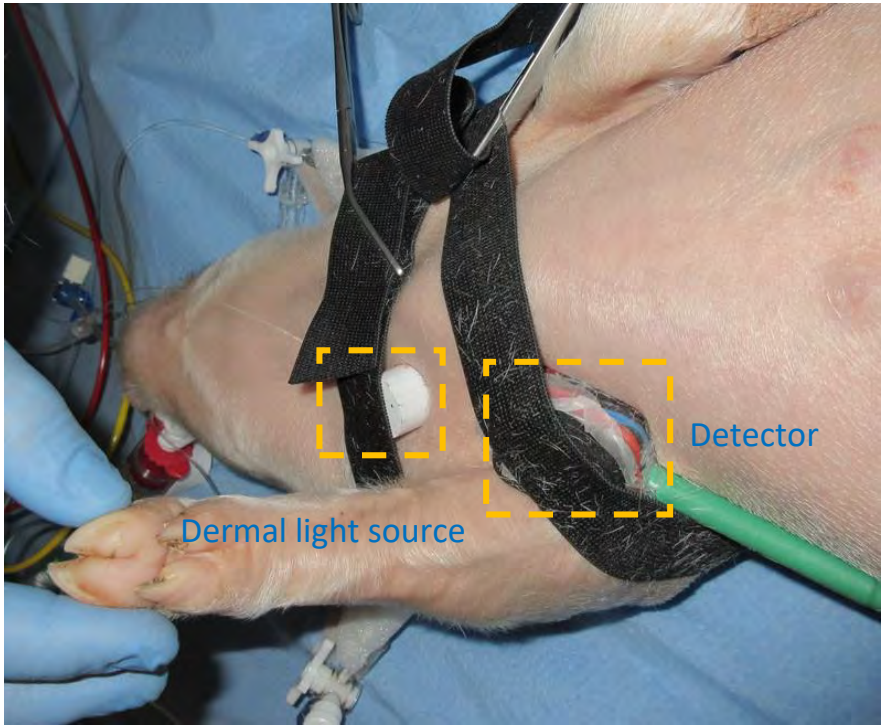
The internal light illumination resulted in higher absorption and better signal-to-noise-ratio as compared to dermal illumination

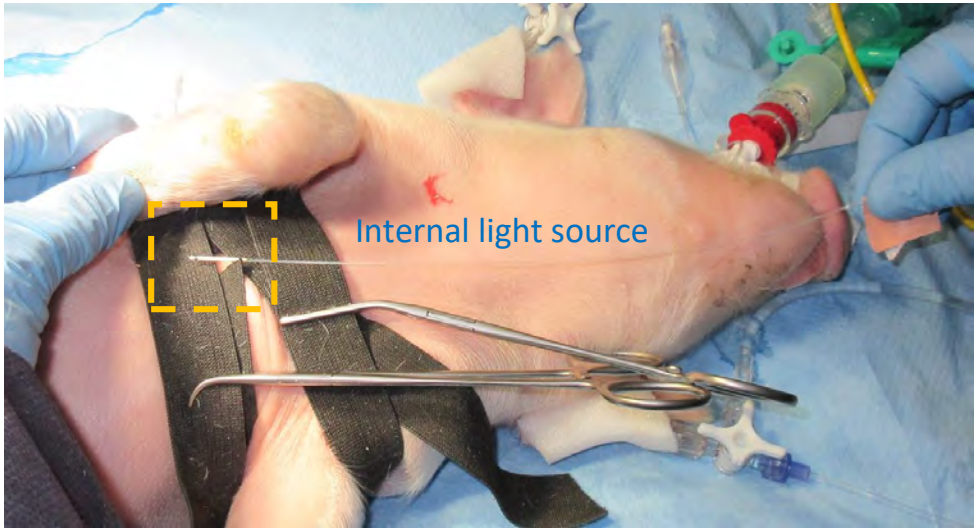
S. Svanberg, E. Krite Svanberg, M. Larsson
System and method for laser based internal analysis of gases in a body. Extended PCT application No: PCT/EP2016/069549

Larsson J. et al. (Accepted, J. BioPhotonics, March 2019)

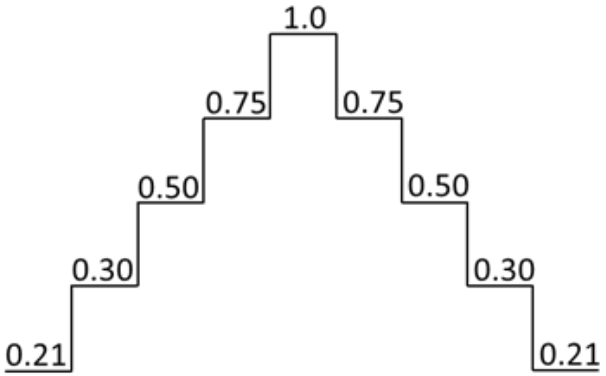
Piglet studies

Light source - dermal vs internal

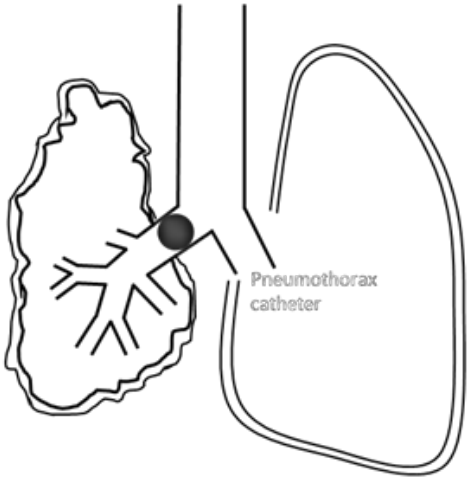




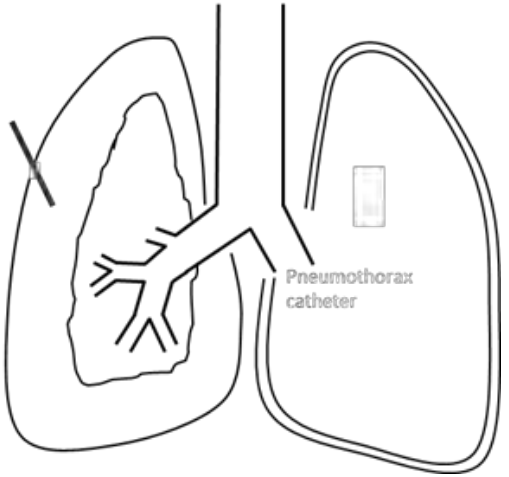
a) FiO_2 challenge

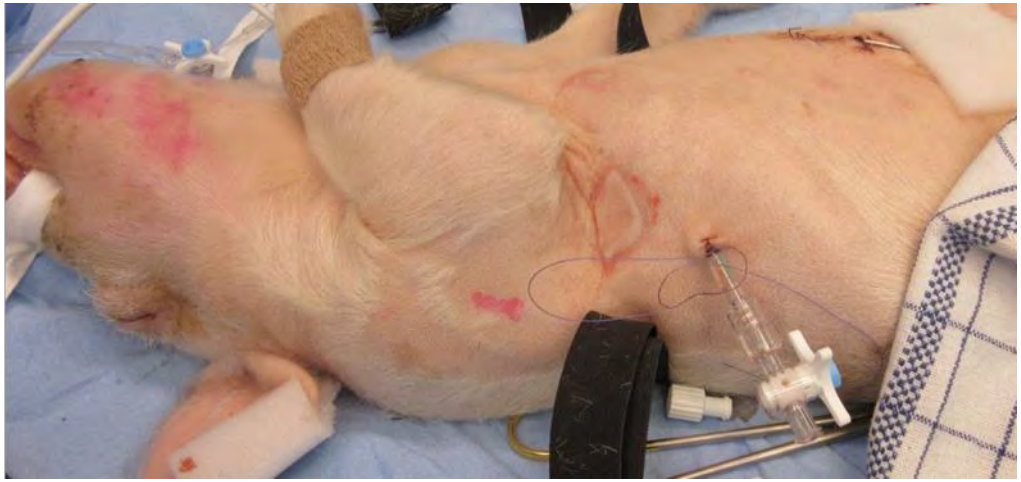


b) Atelectasis



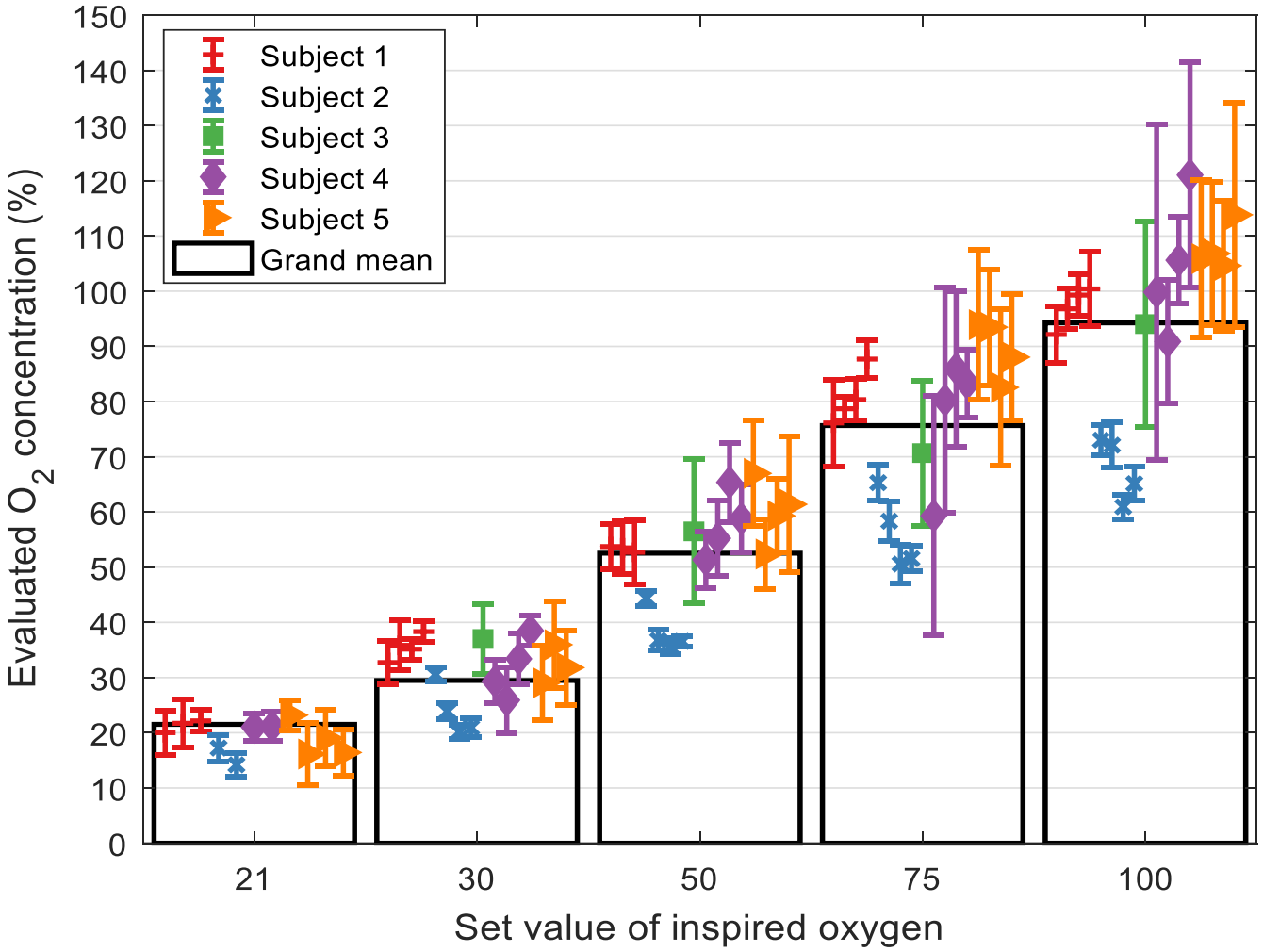
c) Pneumothorax



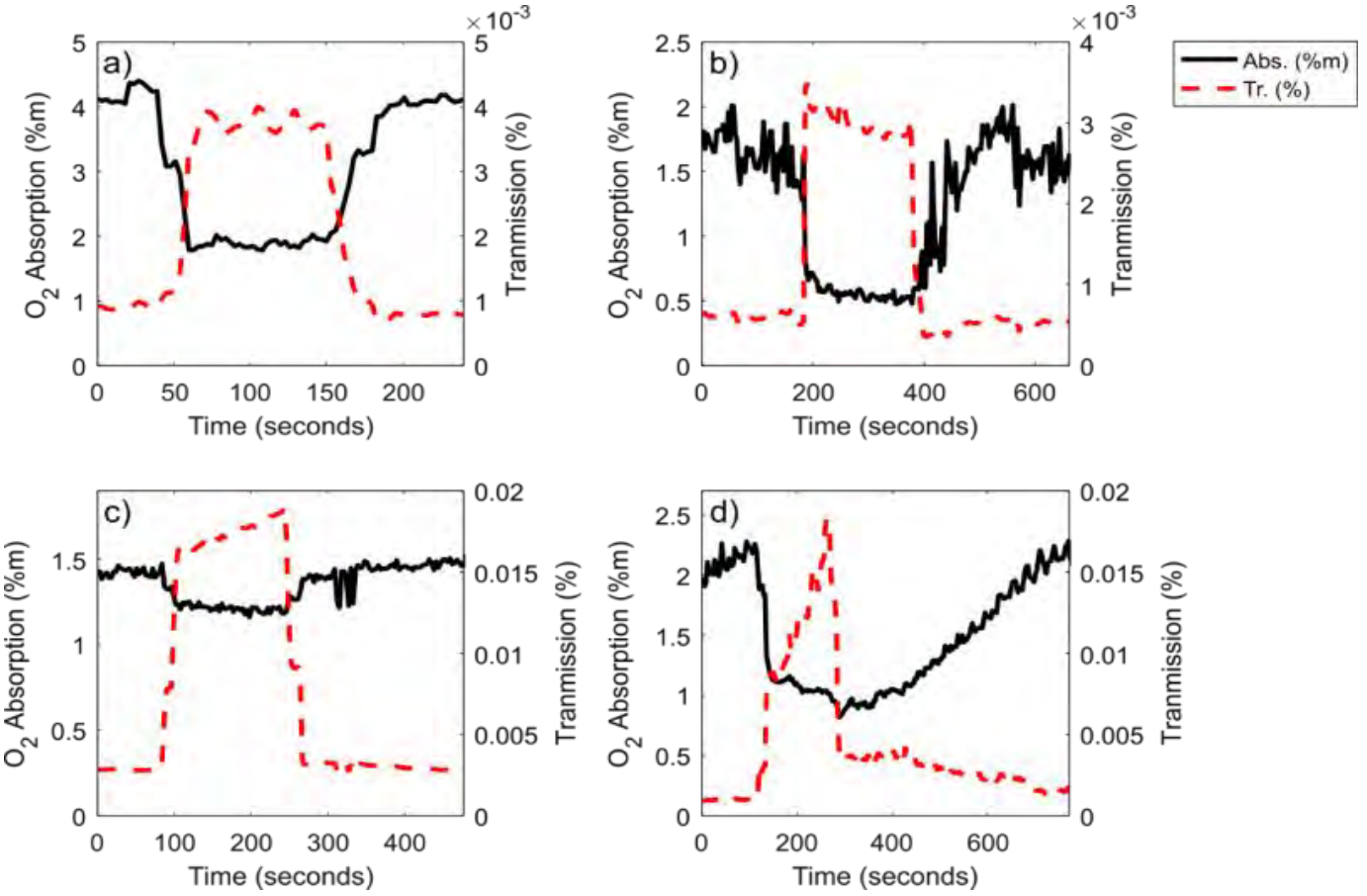


Pneumothorax

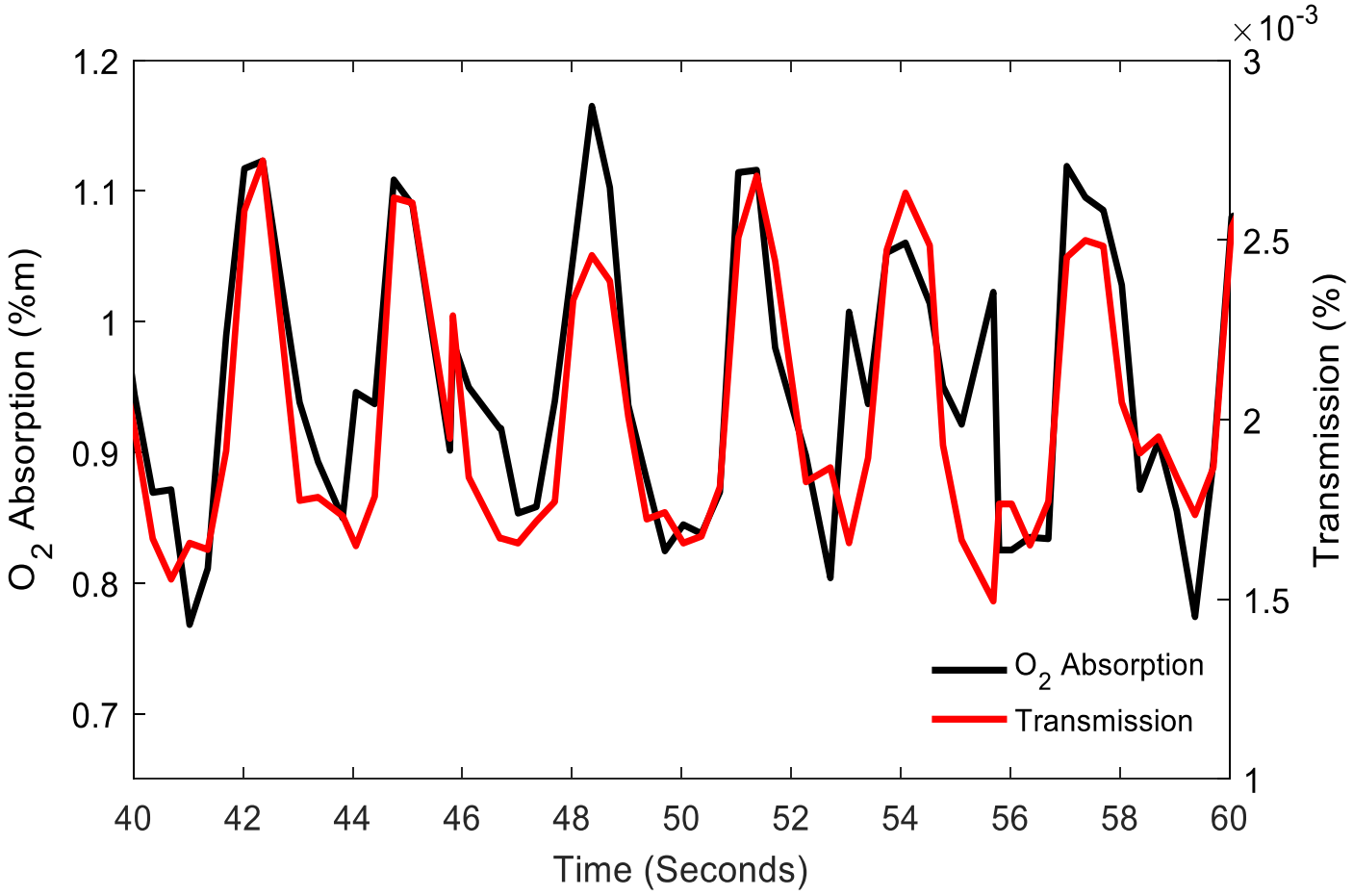
Evaluated O_2 concentration



Pneumothorax



Breath-by-breath



Optical measuring probes

Encouraging results!

- Continuation with oxygen and lung volume measurements in premature infant lungs
- Detection of lung complications
- Potential for an ”optical stetoscope”
- Minimize the need of potentially harmful investigations

- GASMAS could be a valuable complement in the surveillance and treatment evaluation in premature, critically ill infants

Ongoing activities

Broad-band spectroscopy

- Light propagation studies in optical phantoms with pTOFS
- Further comparative studies with pTOFS and a more refined CW-NIRS on healthy volunteers
- Blood-lipid phantom studies combining pTOFS and CW-NIRS
- Comparisons pTOFS - photoacoustics

Narrow-band spectroscopy

- Further piglet studies for optimal detection of lung complications
- Patient studies in prematurely born infants at the Neonatal Unit, Lund

Thanks to my co-workers

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- Chen Xu
- Brian Angeli

Thank you for your attention!