LEA Medizintechnik

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**Title**

Determination of oxygen metabolism in tissues by combined white light spectrometry and laser spectroscopy – an overview about method and study results.

**Key Technologies**

- Laser Spectroscopy
- White Light Spectrometry
- Glas Fibre Technology
- Optical Sensors (worldwide patents)
O2C (oxygen to see)

- Laser- and White-light spectroscopy
- Continuous monitoring of
  - Blood flow (capillary microcirculation)
  - Venular oxygen saturation (hypoxia)
  - Capillar-venular filling with blood (venous congestion)
- 50 ms measurement time
- Depth selective (e.g. skin, muscle, bone) 100 µm - 15 mm

Disadvantages
- No images
Tissue Spectroscopy and -Spectrometry

- Light Scattering on Mitochondria
- Schematic path of photons in tissue
- Changed in color and intensity
- Erythrocytes
- Blood vessels
- Changed in frequency ($f_2 = f_1 + \Delta f$)

- Laser-light
- White light
- Colored light
- SO$_2$ relHb
- Flow Velocity
- Tissue

In the diagram, the path of photons in tissue is illustrated, along with changes in color and intensity, and the effects of light scattering on mitochondria. The diagram also shows the relationship between different wavelengths ($\lambda$) and the frequency shifts ($f_1$, $f_2$).
Comparison: tcpO₂ and O2C

Measurement area pO₂ electrode

Linear Haemoglobin Saturation (SO₂)

Exponential pO₂ Gradients

Arteriole Capillaries Venule

3 % physically solved oxygen

1.8 %

1.5 %

1.2 %

Measurement area O2C (oxygen to see)

Lethal Corner Last meadow

11 %

16 %

73 %

Comparison: tcpO₂ and O2C
The Impact of O2C for the Quantification of Tissue Ischemia in Diabetic Foot Ulcers (Diabetes Care, Vol. 27, Dec. 2004)

- Patient lying on his back
- Start of measurement after 10 minutes rest
- Definition of constant measurement time
- Opsite®-Film between wound and probe
- Same application pressure of the probe by fixation of the probe with Opsite®-Film of constant size
- No movement of the extremities during measurement

S. Beckert, A. Königsrainer, M. Witte, S. Coerper
Universitätsklinikum Tübingen, Klinik für Allgemeine Chirurgie

“The O2C is a reliable and valid method, for the assessment of tissue microperfusion. Measurements are easy to perform and not time consuming. Results are accurate … detect clinically relevant ischemia earlier, predict the future healing process and choose appropriate treatment schedule”

Fig. 2:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SO2 [%]</th>
<th>rHb [AU]</th>
<th>Flow [AU]</th>
<th>Velocity [AU]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healer</td>
<td>70</td>
<td>50</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Non-healer</td>
<td>70</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-healer</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n-h</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n-h</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

diabetes patient, tcpO2 < 30 mmHg, nonpalpable peripheral pulse, grad I ulcers, measures at the wound site, significant at all parameters
Amputation level assessment using lightguide spectrophotometry

Prosthet Orthot Int 1995 Dec;19(3):139-47
Amputation level assessment using lightguide spectrophotometry.
Harrison DK, McCollum PT, Newton DJ, Hickman P, Jain AS

Criteria for amputation due to insufficient wound healing
- Mean value smaller than 30% in SO2 and
- Lowest values below 10% SO2 more than 3 out of 20 values.

The combination of these criteria gave a sensitivity and selectivity of 1.0 for prediction of a successful outcome of transtibial amputations.

Investigation scheme on the lower leg,
- 10 locations on a circle and
- 10 locations in a row
Parameters of Microcirculation and Healing Time of Burn Wounds

On 15 patients, 86 burn wounds were examined. The wounds were clinically evaluated and examined additionally with the O2C (LEA Medizintechnik GmbH). The measurements were conducted within 24 hours and 3 days after the day of burn. The wounds were divided into 4 groups (healing time 1-2 weeks, 2-3 weeks, >3 weeks, and operated wounds).

The groups marked by $\uparrow$ are showing a significant reduction (p<0.05) of flow and velocity values compared to the other groups. The haemoglobin concentration and oxygen saturation of the operated group were significantly lower than the group with 2-3 weeks healing. Neither flow, velocity, Hb concentration nor oxygen saturation were showing significant changes between the measurements on the first and the third day after burn.

“Retrospective analysis shows a correlation between healing time and flow and velocity.”
Increase microvascular permeability and perfusion mismatch are hallmarks of sepsis and septic shock

B. Brell, B. Temmesfeld-Wollbrück, et al. Department of Internal Medicine/Infection Diseases, University Medicine Berlin, Germany
Crit. Care Med. 2005 Vol. 33, No.4 pp 819-826
Adrenomedullin reduces Staphylococcus aureus α-toxin-induced rat ileum microcirculatory damage

Measures in mucosa show good correlation between perfusion pressure (SMA-Pressure) and mucosal oxygen saturation SO2 (mHbO2) measured by O2C

Measures on mucosa show good correlation between
• amount of hemoglobin rel.Hbcon
• gain in weight of the gut

-> (venous congestion, edema)
Oxygen Saturation of mucosa of stomach in healthy persons (A) and patients with sepsis (B) taken from (10) recorded by O2C(oxygen to see)

(10) Am J Respir Crit Care Med 1998 May;157(5 t 1):1586-92
Abnormalities of gastric mucosal oxygenation in septic shock: artial responsiveness to dopexamine.
Temmesfeld-Wollbruck B, Szalay A, Mayer K, Olschewski H, Seeger W, Grimminger F.
Postprandiale Dysfunktion der Mikrozirkulation nach einer Mahlzeit reich an Advanced Glycation Endproducts (AGE) bei Patienten mit Typ 2 Diabetes mellitus - protektive Rolle von Benfotiamin


**Methoden:**

**AGE-reiche Mahlzeit (HAGE):** 15.100 kU AGE gebacken/gebraten - 220°C, 20 Min

**AGE-arme Mahlzeit (LAGE):** 2750 kU AGE gekocht/gedünstet - 100°C, 10 Min

- Eine **AGE-reiche**, Mahlzeit führt zu einem signifikanten **Abfall der Gefäßfunktion der Mikrozirkulation** (O2C oxygen to see), der mindestens 6 Stunden anhält und ausgeprägter ist als nach einer AGE-armen Mahlzeit
- Benfotiamin kann diesen negativen Effekt **reduzieren**
MYOCARDIAL MICROCIRCULATION DURING ISCHEMIC PRECONDITIONING IN OFF-PUMP BYPASS SURGERY

Methods: 21 patients (14 males) scheduled for OPCAB were enrolled in the study. Intraoperatively, the LAD was occluded for 2 min followed by a 2 min reperfusion interval. The procedure was repeated three times.

Tissue SO2 increased going from the first to the third occlusion from 75±11% to 83±8% (p<0.001). rHb as a marker of postcapillary venous haemoglobin concentration increased significantly (77±8 vs. 85±6, p=0.002). Superficial and deep myocardial blood flow decreased significantly (317±17 vs. 308±36, p <0.001; 402±56 vs. 350±50, p < 0.001; respectively).

"Oxygen-to-see system is capable of detecting myocardial microcirculation in vivo real time.

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Conclusions

Remission spectroscopy (O2C) represents a simple and reliable method for hepatic sinusoidal SO2 determination.

Significant reduction in hepatic SO2 during early stages of systemic inflammation in parallel an increasing NAD(P)H autofluorescence (=inadequate oxygen supply)
O2C (oxygen to see) Monitoring on mouth mucosa during bypass surgery

- Stop of HLM (8 sec.)
- Bolus of NO
- Spreading of thorax
O2C (oxygen to see) probe in rectum, Bad Oeynhausen, Patient on HLM, Hypothermia 30 C
Influence of haemorrhagic shock on fracture healing

M. Bumann, T. Henke, H. Gerngross, L. Claes, P. Augat, Department of Orthopaedic Research and Biomechanics, Uni Ulm, Germany

Measurement at the level of fracture (tibia), 1cm distal/proximal and soft tissue with O2C(oxygen to see)
Shock group with volume resuscitation
Control group without

Shock group with volume substitution has no reduction in blood flow in the distal and soft tissue regions and shows a better fracture healing outcome.

Flexural rigidity

- Shock group: 4x in fractured bones
- Control group: 3x in fractured bones

Failure load

- Shock group: 3x in fractured bones
- Control group: 4x in fractured bones
Monitoring of regional circulatory system - on a functional basis
Probetypes
- Flat probes for skin and muscle (e.g. 2 and 8 mm depth)
- Muscle probe 15 mm depth
- Micro-probes 0.8 mm and 2.3 mm diameter
- Redong probe for buried flaps and transplants (monitoring)
Thank you

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