NEAR-INFRARED SPECTROSCOPY: APPLICATIONS IN PEDIATRIC ANESTHESIA AND BEYOND

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Background

- How it works
  - Near-infrared light emitted from source → penetrates skull → absorbed by Hgb → reaches detectors

- Differences from pulse oximetry
  - 70-75% venous sampling
  - Does not require pulsatile flow

- Frontal cortex has limited oxygen reserve so decreased cerebral O2 sat may be early warning

- Measures to increase cerebral O2
  - Increase MAP
  - Increase FiO2
  - Increase PaO2
  - Increase Hgb
NIRS vs. SvO$_2$, SjO$_2$

Nagdyman et al. 2008

rSO$_2$/SjO$_2$

$R = 0.83$

rSO$_2$ correlates with systemic and jugular venous saturation

rSO$_2$/SvO$_2$

$R = 0.93$

Nagdyman et al. 2008
NIRS and tissue injury

Kurth et al. 2009

ScO2 vs. tissue lactate

Threshold for biochemical dysfunction ScO2 ~ 35-45%

Kurth et al. 2002

Abnormal neurologic outcome vs. HI time

Time threshold for ScO2 < 35% for ischemic damage ~ 2hrs

Kurth et al. 2009
NIRS and outcomes in cardiac surgery

### Table VI. Effect of neurophysiologic monitoring on neurologic complication and length of hospital stay

<table>
<thead>
<tr>
<th>Neurocomplication</th>
<th>No change (No. [%])</th>
<th>Intervention (No. [%])</th>
<th>No intervention (No. [%])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seizure</td>
<td>5/74 (7%)</td>
<td>7/130 (6%)</td>
<td>12/46* (26%)</td>
</tr>
<tr>
<td>Cerebral infarct</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Chorea</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Visual neglect</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hypotonia</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Speech disorder</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Length of stay: median</td>
<td>6 (4-12)</td>
<td>6 (5-12)</td>
<td>9 (5-13)†</td>
</tr>
<tr>
<td>(interquartile range)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent discharged &lt; 7 days</td>
<td>58</td>
<td>51</td>
<td>32‡</td>
</tr>
</tbody>
</table>

*Intervention for cerebral monitoring events associated with improved outcome

\* p = 0.003 versus intervention; \( p = 0.01 \) versus no change.
\† median (interquartile range); no significant intergroup differences.
\‡ p = 0.05 versus intervention; \( p = 0.01 \) versus no change.

Austin et al. 1997
Cerebral desaturation and long term outcomes

Lower Psychomotor Development Index a/w lower rSO2 60 min after separation from bypass

Kussman et al. 2010
Somatic – Cerebral rSO2 difference

Complications, Shock, Mortality vs. Somatic-Cerebral rSO2 difference in children undergoing stage 1 palliation for CHD

Hoffman et al. 2004, 2007

Somatic – cerebral rSO2 difference < 10 indicates somatic ischemia
Cerebro-splanchnic oxygenation ratio

TOI<sub>abd</sub>/TOI<sub>brain</sub> for controls and acute abdomen

CSOR < 0.75 indicates increased splanchnic oxygen extraction ~ Intestinal ischemia
- Sensitivity 0.90, Specificity 0.96

Fortune et al. 2001
NIRS in acute hemorrhage

Cerebral and somatic rSO2 decrease in acute hemorrhage – Somatic rO2 more sensitive

Torello et al. 2002

Fig. 2. Changes from baseline for CsO2 (↓) and PsO2 (↓). Values are means and 95% CI. Both trends were statistically significant (P < 0.001,
**NIRS in Dehydration**

**TABLE 3. Change in rSO₂ With Rehydration**

<table>
<thead>
<tr>
<th></th>
<th>Prehydration, Mean (SD)</th>
<th>Posthydration, Mean (SD)</th>
<th>Mean Change (Posthydration − Prehydration)</th>
<th>Paired t Test, $P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_pO_2$</td>
<td>98.2 (1.0)</td>
<td>98.5 (1.7)</td>
<td>0.3</td>
<td>NS</td>
</tr>
<tr>
<td>Cerebral rSO₂</td>
<td>74.5 (11.4)</td>
<td>73.6 (10.0)</td>
<td>−0.9</td>
<td>NS</td>
</tr>
<tr>
<td>Somatic rSO₂,* %</td>
<td>78.9 (13.3)</td>
<td>87.0 (9.3)</td>
<td>8.1*</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Somatic-cerebral rSO₂</td>
<td>4.6 (7.2)</td>
<td>13.4 (6.6)</td>
<td>8.8*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>difference,* %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regional $O_2$ extraction, † %</td>
<td>19.3 (13.1)</td>
<td>11.4 (8.4)</td>
<td>−7.9†</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Increased value suggests improved regional blood flow.
†Regional $O_2$ extraction = $S_pO_2$ – somatic rSO₂; a fall in extraction with unchanged $S_pO_2$ suggests improved regional perfusion.

Hansen et al. 2009

Somatic rSO₂ and Somatic-Cerebral rSO₂ difference increase with rehydration
NIRS in Septic Shock

Payen et al. 2009

StO2 reperfusion slope differentiates septic vs. healthy patients
Some adult studies
Cerebral Oxygen Desaturation Predicts Cognitive Decline and Longer Hospital Stay After Cardiac Surgery

James P. Slater, MD, Theresa Guarino, RN, Jessica Stack, BS, Kateki Vinod, BA, Rami T. Bustami, PhD, John M. Brown III, MD, Alejandro L. Rodriguez, MD, Christopher J. Magovern, MD, Thomas Zaubler, MD, Kenneth Freundlich, PhD, and Grant V.S. Parr, MD
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Monitoring Brain Oxygen Saturation During Coronary Bypass Surgery: A Randomized, Prospective Study

John M. Murkin, MD, FRCPC*

Sandra J. Adams, RN*

BACKGROUND: Cerebral deoxygenation is associated with various adverse systemic outcomes. We hypothesized, by using the brain as an index organ, that interventions to improve cerebral oxygenation would have systemic benefits in cardiac surgical patients.
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Continuous Monitoring of Cerebral Oxygen Saturation in Elderly Patients Undergoing Major Abdominal Surgery Minimizes Brain Exposure to Potential Hypoxia
Andrea Casati, MD*, Guido Fanelli, MD*, Paolo Pietropaoli, MD†, Rodolfo Proietti, MD†, Rosalba Tufano, MD§, Giorgio Danelli, MD*, Giuseppe Fierro, MD†, Germano De Cosmo, MD†, and Giovanni Servillo, MD§, on behalf of the Collaborative Italian Study Group on Anesthesia in Elderly Patients

Monitoring Intracranial Pressure After Bypass Surgery
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Noninvasive tissue oxygen saturation determined by near-infrared spectroscopy following peripheral nerve block

P.J. Tighe¹, C.E. Elliott¹, S.D. Lucas¹ and A.P. Boezaart¹²
Other applications

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The SafeBoosC Phase II Randomised Clinical Trial: A Treatment Guideline for Targeted Near-Infrared-Derived Cerebral Tissue Oxygenation versus Standard Treatment in Extremely Preterm Infants

Adelina Pellicer¹ Gorm Greisen² Manon Benders³ Olivier Claris⁴ Eugene Dempsey⁵
Monica Fumagalli ¹ Christian Gluud ⁹ Comelia Hagmann ¹² Lena Hellström-Westas ¹
Simon Hyttel-Sorensen ² Petra Lemmers³ Gunnar Naulaers¹ Gerhard Pichler⁶
Claudia Roll¹ Frank van Bel³ Wim van Oeveren²⁹ Maria Skoog⁸ Martin Wolf¹
Topun Austin⁰ and the SafeBoosC Trial Group
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Cerebral oxygen saturation monitoring in pediatric altered mental status patients

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Cerebral Oximetry Monitoring During Preoperative Phlebotomy to Limit Allogeneic Blood Use in Patients Undergoing Cardiac Surgery

Elisabeth Dewhirst, Peter Winch, Aymen Naguib, Mark Galantowicz, Joseph D. Tobias

Adelina Pellicer a, Gorm Green, Monica Fumagalli f, Christian Hertzberg, Simon Hyttel-Sorensen b, Petra Zerhner, C. Chris Pedersen, Gerhard Fichert, Claudia Roll i, Frank van Bel c, Wim van Oeveren m, Maria Skoog o, Martin Wolf n, Topun Austin o, and the SafeBoosC Trial Group


References