Prolonged cerebral desaturation during on-pump coronary artery bypass graft (CABG) and valve replacement surgeries has been linked to negative and costly postoperative patient outcomes, such as neurological deficit and prolonged hospital stay. In addition, prolonged cerebral hyperoxygenation — with and without prior cerebral desaturation — is an independent predictor of postoperative delirium.

Several studies have shown up to a 97% success rate in reversing cerebral desaturation events during cardiac surgery by pairing the INVOS™ cerebral/somatic oximeter with an interventional algorithm to restore baseline cerebral oxygen saturation.

The randomized, controlled studies outlined in this clinical evidence guide have shown that monitoring and intervention improve postoperative outcomes, such as:

- Postoperative cognitive decline
- ICU length of stay
- Major organ morbidity and mortality
Monitoring with INVOS™ technology indicates that desaturations occur in 50% to 75% of patients during on-pump cardiac surgery and interventions are effective at reversing desaturations.

A multicenter pilot study assessing regional cerebral oxygen desaturation frequency during cardiopulmonary bypass and responsiveness to an intervention algorithm


<table>
<thead>
<tr>
<th>Study design</th>
<th>Multicenter, prospective, observational pilot study (United States)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arms</td>
<td>Single arm: INVOS™ monitoring technology</td>
</tr>
</tbody>
</table>
| Objectives  | • Determine the frequency of desaturation events during on-pump cardiac surgery  
• Determine how accurately clinicians identify desaturations compared to NIRS monitoring  
• Evaluate an intervention algorithm for reversing desaturations |
| N           | 235                                                           |
| Population  | CABG and/or cardiac valve surgery patients                    |
| Definition of desaturation | <80% of baseline rSO₂                              |
| Threshold for intervention | <80% of baseline rSO₂                                  |
| Results     | • Across all institutions, 61% (95% confidence interval, 50% to 75%) of patients experienced at least one desaturation  
• Clinicians identified 89.5% (340/380) of the desaturation events detected by NIRS monitoring  
• Of the 340 clinician-identified desaturations:  
  – 115 resolved with usual clinical care  
  – 225 were treated according to the intervention algorithm  
    • Treating hypotension was the most effective intervention (correcting 29.8% desaturations)  
  – In 18 patients the desaturation was unresolved |
| Conclusions | Desaturations occur in 50% to 75% of cardiac surgery patients during cardiopulmonary bypass. About 10% of desaturations were detected by the NIRS monitor but not recognized by the clinician. An intervention algorithm effectively reversed the majority of clinician-identified desaturation events. |
Monitoring with INVOS™ technology reveals that intraoperative cerebral hyperoxia is independently associated with increased odds of postoperative delirium.

Intraoperative cerebral oxygenation, oxidative injury, and delirium following cardiac surgery
Lopez MG, Pandharipande P, Morse J, et al.

<table>
<thead>
<tr>
<th>Study design</th>
<th>Single-center, cohort study from the Statin AKI Cardiac Surgery randomized controlled trial (United States)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arms</td>
<td>Single arm: INVOS™ monitoring technology</td>
</tr>
<tr>
<td>Objective</td>
<td>Determine whether intraoperative hyperoxic cerebral reperfusion is associated with increased postoperative delirium</td>
</tr>
<tr>
<td>N</td>
<td>310</td>
</tr>
<tr>
<td>Population</td>
<td>CABG, heart valve, or ascending aortic surgery patients</td>
</tr>
</tbody>
</table>
| Definitions of intraoperative hypoxic and hyperoxic states | Hypoxia: rSO₂ <80% of baseline  
Ischemia: rSO₂ = 80% of baseline >5 min (or equivalent area under the curve [AUC] for <80% of baseline)  
Hyperoxia: any rSO₂ greater than baseline before any ischemia or in patients who had not experienced ischemia  
Hyperoxic cerebral reperfusion: any rSO₂ greater than baseline after cerebral ischemia (AUC above baseline) |
| Threshold for intervention | ≤80% of baseline rSO₂  
No intervention when rSO₂ was greater than baseline |
| Results      | • 29% (90/310) of patients developed postoperative delirium  
• 51.3% (159/310) experienced intraoperative cerebral ischemia  
• 30.3% of patients experiencing ischemia (94/159) became hyperoxic  
• Every 10% · hour of both hyperoxia and hyperoxic cerebral reperfusion were independently associated with increased odds of postoperative delirium (OR = 1.10, p = 0.02; and OR = 1.65, p = 0.01; respectively)  
• There was no association between ischemia and delirium |
| Conclusions  | The magnitudes of intraoperative cerebral hyperoxia and hyperoxic reperfusion (but not ischemia) were associated with postoperative delirium. This may suggest changes for perioperative management to avoid hyperoxygenation. |
Monitoring with INVOS™ technology and intervention to restore cerebral oxygen saturation levels during CABG surgery is associated with a reduction in ICU length of stay and the incidence of MOMM.†

Monitoring brain oxygen saturation during coronary bypass surgery: a randomized, prospective study
Murkin JM, Adams SJ, Novick RJ, et al.

<table>
<thead>
<tr>
<th>Study design</th>
<th>Single-center, prospective, randomized controlled trial (Canada)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arms</td>
<td>CONTROL: blinded INVOS™ monitoring technology&lt;br&gt;INTERVENTION: INVOS™ monitoring technology and use of an interventional algorithm to restore rSO₂</td>
</tr>
<tr>
<td>Objective</td>
<td>Detect 40% incidence of overall complications with a 50% relative reduction in complications using cerebral oximetry with an interventional algorithm</td>
</tr>
<tr>
<td>N</td>
<td>200</td>
</tr>
<tr>
<td>Population</td>
<td>On-pump CABG patients</td>
</tr>
<tr>
<td>Definition of desaturation</td>
<td>&lt;70% of baseline rSO₂ for &gt;1 minute</td>
</tr>
<tr>
<td>Definition of prolonged desaturation</td>
<td>AUC of &lt;70% of baseline &gt;150% ∙ minute</td>
</tr>
<tr>
<td>Threshold for intervention</td>
<td>&lt;75% of baseline rSO₂ for &gt;15 seconds</td>
</tr>
<tr>
<td>Results</td>
<td>Monitoring and intervention was associated with:&lt;br&gt;– Lower rate of 30-day MOMM (3% vs. 11%; p = 0.048)&lt;br&gt;– Shorter ICU length of stay (1.25 vs. 1.87 days; p = 0.029)&lt;br&gt;– Lower incidence of prolonged desaturation (0% vs. 6%; p = 0.014)&lt;br&gt;• There was a significant inverse correlation (r = 0.29; p &lt; 0.05) between mean intraoperative rSO₂ and hospital length of stay in patients requiring hospitalization ≥10 days</td>
</tr>
<tr>
<td>Conclusions</td>
<td>Monitoring of cerebral oxygenation and intervening to restore desaturation during CABG surgery was associated with a decreased rate of MOMM and shorter ICU length of stay.</td>
</tr>
</tbody>
</table>

† MOMM is a composite endpoint of outcomes including death, prolonged ventilation, stroke, myocardial infarction, and return for re-exploration.
Monitoring with INVOS™ technology and intervention to restore cerebral oxygen saturation levels during CABG surgery is associated with a reduction in postoperative cognitive dysfunction.

Influence of intraoperative cerebral oximetry monitoring on neurocognitive function after coronary artery bypass surgery: a randomized, prospective study

<table>
<thead>
<tr>
<th>Study design</th>
<th>Single-center, prospective, randomized controlled trial (Croatia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arms</td>
<td>CONTROL: no monitoring</td>
</tr>
<tr>
<td></td>
<td>INTERVENTION: INVOS™ monitoring technology and use of an interventional algorithm to restore rSO₂</td>
</tr>
<tr>
<td>Objective</td>
<td>Detect 50% incidence of postoperative cognitive dysfunction (POCD) decreasing to 30% using INVOS™ monitoring technology with a interventional algorithm</td>
</tr>
<tr>
<td>N</td>
<td>200</td>
</tr>
<tr>
<td>Population</td>
<td>On-pump CABG patients</td>
</tr>
<tr>
<td>Definition of desaturation</td>
<td>&lt;80% of baseline rSO₂, or an rSO₂, &lt;50% &gt;1 minute</td>
</tr>
</tbody>
</table>
| Definition of prolonged desaturation | • AUC of rSO₂ values <80% of baseline of 150% · min  
• AUC of rSO₂, values <50% of 50% · min |
| Threshold for intervention | <80% of baseline rSO₂, or an rSO₂, <50% |
| Results     | • Patients randomized to monitoring and intervention had a lower rate of POCD 7 days after surgery (28% vs. 52%, p = 0.002) 
• Patients with prolonged desaturation had higher risk of cognitive decline (OR = 12.1, p = 0.003) |
| Conclusions | Monitoring cerebral oxygenation and intervening to restore desaturation during CABG surgery was associated with a decrease in the incidence of POCD. |
A selection of clinical studies using INVOS™ technology intraoperatively in CABG and valve surgery patient populations


References


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