Clinical Evidence Guide

MONITORING SOMATIC PERFUSION IN CARDIOTHORACIC SURGERY

How the INVOS™ cerebral/somatic oximeter can help

Paraparesis and paraplegia are uncommon but devastating side effects of spinal cord ischemia and infarction during thoracoabdominal aortic aneurysm repair (TAAA). Near infrared spectroscopy (NIRS) is emerging as a noninvasive tool to identify spinal cord ischemia during the perioperative period of open and endovascular TAAA repairs. Animal modeling suggests that regional oxygen saturation (rSO₂) of the paraspinous collateral network — as measured with the INVOS™ cerebral/somatic oximeter — can serve as a surrogate measure of spinal oxygen status.

In these animal and human studies, the monitoring setup included INVOS™ sensors over either the lower thoracic or lumbar vertebral regions to detect spinal ischemia in the repair area. Sensors over the upper thoracic vertebral areas served as a control for global fluctuations in perfusion not related to the repair.
Decreased lower thoracic rSO$_2$ values were observed in an endovascular T AAA repair patient with postoperative loss of lower extremity motor function.

*Use of spinal near-infrared spectroscopy for monitoring spinal cord perfusion during endovascular thoracic aortic repairs.*
Badner NH, Nicolaou G, Clarke CF, Forbes TL.

<table>
<thead>
<tr>
<th>Study design</th>
<th>Case description (Case 2 in the publication – Canada)</th>
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</table>
| Patient description | • 76-year-old female  
• Asymptomatic 7.5 cm T AAA from the origin of the left subclavian artery to the abdominal aorta distal to the renal arteries |
| Surgical approach | Endovascular aortic repair of T AAA (deployed as two grafts) |
| Monitoring approach | • INVOS™ sensors placed over the spine spanning the T1–T3 region (control), and the T8–T10 region (at risk for desaturation)  
• Transcranial motor evoked potential (MEP) monitoring of both adductor hallucis (AH) muscles |
| Intervention | Cerebral spinal fluid drainage, blood pressure management, and transfusion |
| Results | **Baseline**  
• Upper thoracic rSO$_2$: 85%–90%  
• Lower thoracic rSO$_2$: 80%–85%  
**After deployment of the second graft**  
• AH MEPs were absent  
• Spinal rSO$_2$ gradually dropped to the 60s for the upper sensor and 30s in the lower sensor  
• Intervention caused no change to the AH MEPs, and the lower thoracic rSO$_2$ did not rise above 50%  
**Postsurgery**  
• No motor function in lower extremities and loss of sensation  
• Prolonged hospitalization  
• Discharge to a spinal rehabilitation center  
Case 1 (not reported above) experienced a lower thoracic spinal desaturation event during graft deployment, which improved with intervention. This patient did not suffer any postoperative neurological dysfunction. MEPs were not monitored in this patient.  
**Conclusions**  
Spinal oximetry using NIRS technology can be considered a useful tool for real-time monitoring for ischemia, although AH MEPs were the first to change.
The upper/lower thoracic rSO$_2$ ratio was significantly lower in patients with MEP ratios less than 50%.

**Spinal near-infrared spectroscopy measurements during and after thoracoabdominal aortic aneurysm repair: a pilot study.**


<table>
<thead>
<tr>
<th>Study design</th>
<th>Single-center, prospective observational study (The Netherlands)</th>
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<tbody>
<tr>
<td>Arms</td>
<td>Single arm: INVOS™ monitoring system</td>
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| Objective    | 1. Determine the feasibility of NIRS to monitor tissue oxygenation in the upper (T3) and lower (T12) thoracic spinal regions (expressed as a ratio of T12/T3 rSO$_2$, to account for systemic rSO$_2$ fluctuations) throughout the perioperative period  
2. Examine the association between rSO$_2$ and MEP (separated into patient groups with MEP ratios of <50% or ≥50%) |
| N            | 15                                                               |
| Population   | Open thoracic aneurysm or TAAA repair                            |
| Threshold for intervention | No interventions were made based on rSO$_2$ values |
| Results      | • Continuous NIRS monitoring was successfully carried out for all 15 patients during surgery and for 24 hours postoperatively in the ICU without disrupting routine care  
• Two patients experienced clinically relevant desaturation events  
• The mean T12/T3 rSO$_2$ ratio was lowest during the staged aortic cross-clamp compared to baseline  
• Continuous MEP monitoring in the OR was unsuccessful in 20% (3/15) of patients due to interference of anesthetics or temporary peripheral/nonspinal ischemia  
• Five patients had continuous MEP ratios in both the <50% or ≥50% groups and were included for comparison against T12/T3 ratios  
  – Mean T12/3 rSO$_2$ ratio in the <50% MEP group of measurements was 85.2%  
  – Mean T12/3 rSO$_2$ ratio in the ≥50% MEP group of measurements was significantly higher at 94.6% (p = 0.037) |
| Conclusions  | NIRS monitoring can be considered a reliable and noninvasive method to monitor spinal cord ischemia throughout the perioperative period. |
Patients with postoperative paraparesis or paraplegia had significantly lower lumbar rSO$_2$ after aortic cross-clamping.


<table>
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<th>Study design</th>
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<td>Arms</td>
<td>Single arm: INVOS™ monitoring system</td>
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<tr>
<td>Objective</td>
<td>Determine the feasibility of NIRS to monitor tissue oxygenation bilaterally in the thoracic (T5–T7) and lumbar (L1–L3) spinal regions throughout the perioperative period</td>
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<tr>
<td>N</td>
<td>20</td>
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<tr>
<td>Population</td>
<td>Open (15), endovascular (3), or hybrid (2) thoracic aortic or TAAA repair</td>
</tr>
<tr>
<td>Threshold for intervention</td>
<td>No interventions were made based on rSO$_2$ values</td>
</tr>
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</table>
| Results      | • Thoracic rSO$_2$ levels did not change significantly during the perioperative period
  • Lumbar rSO$_2$ levels dropped significantly to 74.1% of the baseline value ($p = 0.02$) upon proximal aortic cross-clamping
  • Of the 17 patients with open or hybrid TAAA repair:
    – 18% (3/17) of patients developed postoperative paraplegia or paraparesis
    – Patients that developed postoperative paraplegia/paraparesis had a significantly lower lumbar rSO$_2$ (after aortic cross-clamping and before distal perfusion was initiated) compared to those who did not (58.3% vs. 85.2%; $p = 0.041$)
  • Monitoring was successfully continued out to 48 hours postoperatively |
| Conclusions  | Noninvasively monitoring rSO$_2$ in the tissue surrounding the spinal cord with NIRS is feasible through the perioperative period. |
Spinal collateral network rSO$_2$ is representative of lumbar muscle and spinal cord oxygenation in a porcine model.


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<th>Study design</th>
<th>Animal study (The Netherlands)</th>
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<td>Objective</td>
<td>Compare laser Doppler flowmetry (LDF) — a validated measure of direct flow and oxygenation — to spinal collateral network rSO$_2$.</td>
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<tr>
<td>N</td>
<td>7 juvenile male pigs</td>
</tr>
</tbody>
</table>
| Description of model | • Pigs were anesthetized and ventilated  
• INVOS™ sensors were placed subcutaneously and bilaterally at the T5–T6 and L2–L3 levels  
• LDF probes were placed directly in the paravertebral muscle and spinal cord  
• Investigators performed a thoracotomy at the seventh intercostal space to expose the thoracic aorta  
• After baseline LDF and rSO$_2$ were determined, aortic cross-clamping was performed and maintained for 8 minutes  
• Cross-clamping was repeated after a recovery period of at least 20 minutes  
• The process was performed four times per pig |
| Results      | • Thoracic rSO$_2$, decreased to ~87% of baseline within 30 seconds of cross-clamping and remained stable until release  
• Lumbar rSO$_2$, decreased to ~69% of baseline within 8 minutes  
• Direct lumbar muscle and spinal cord oxygenation, as measured by LDF, also decreased; both were moderately positively correlated with lumbar rSO$_2$ (r = 0.51–0.52; p < 0.001) |
| Conclusions  | Spinal collateral network rSO$_2$ values reproducibly represent oxygenation of the lumbar muscle and spinal cord, suggesting its possible use for real-time, noninvasive monitoring. |
A selection of clinical studies using INVOS™ technology for somatic monitoring in cardiothoracic surgery


**IMPORTANT:** Please refer to the package insert for complete instructions, contraindications, warnings and precautions.

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