



Case report

Near-infrared spectroscopy provides continuous monitoring of compromised lower extremity perfusion during cardiac surgery^{☆,☆☆}



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Abstract Near-infrared spectroscopy (NIRS) is more frequently used to monitor regional oxygenation/perfusion of the cerebral and somatorenal vascular bed during congenital heart surgery. However, NIRS probes can be placed elsewhere to assess regional perfusion. We report the intraoperative use of NIRS probes on both calves of an infant to continuously monitor changes in the regional oxygenation/perfusion of a lower extremity whose perfusion was compromised after femoral arterial line placement. The NIRS trend of the compromised limb was compared with the contralateral limb throughout congenital heart surgery including the period on cardiopulmonary bypass (CPB). Our case report illustrates that NIRS technology can be used to monitor ongoing lower extremity vascular compromise during congenital heart surgery when it is not practical to directly access and continuously assess the limb. Transient vascular compromise after invasive femoral arterial line or sheath placement for cardiac catheterization in small infants is not infrequent. NIRS technology in such circumstances may help to decide whether watchful waiting is acceptable or immediate interventions are indicated. Continuous NIRS monitoring showed that limb regional oxygenation remained depressed during CPB but dramatically increased in the post-CPB period.

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1. Case description

We received written permission from the mother of this infant to present the following data for publication.

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A 3.5-month-old, 5.2-kg infant with Down syndrome and a large atrioventricular canal defect presented for complete surgical repair. The infant received digoxin and furosemide for treatment of congestive heart failure due to pulmonary overcirculation. Preoperative vital signs included oxygen saturation of 93%, heart rate of 124 beats/min, respiratory rate of 60 breaths/min, and mean arterial blood pressure of 63 mm Hg. Before induction of anesthesia standard noninvasive American Society of Anesthesiologists monitors (electrocardiogram, pulse oximeter, oscillotonometric blood pressure), a frontal cerebral and a right thoracolumbar somatorenal pediatric near-infrared spectroscopy (NIRS) probe (Invo Oximeter 5100C, Somanetics, Troy, MI, USA) were placed.

The patient was induced with sevoflurane (maximal 3.5% end-tidal) 50% oxygen and 50% nitrous oxide. After placement of a right-foot peripheral venous catheter, pancuronium was administered. The patient was intubated nasally with an endotracheal tube, and the anesthetic was maintained with 25% oxygen/nitrogen balance and 1.0% to 2% sevoflurane. A double-lumen right internal jugular central venous line was placed with ultrasound guidance. Because of the NPO status and chronic diuretic use, we assumed that the patient was relatively volume depleted and infused 10 mL/kg (50 mL) of 5% albumin to enhance peripheral pulses prior to percutaneous arterial line placement. This empiric strategy is not based on published data but, in our experience, results in only a small increase in central venous pressure (no change was observed) and a variable increase in NIRS values (a 10-point increase was observed). Multiple bilateral attempts to place a radial arterial line both percutaneously and by surgical cut-down were unsuccessful. Therefore, a percutaneous 3F 8-cm left femoral arterial line (3F single-lumen catheter with an external diameter of 1 mm equivalent to 21 G; Cook Medical, Bloomington, IN) was placed with ultrasound guidance with a single puncture using a 2.5-cm 21-G percutaneous entry thin wall needle (Cook Medical) and the Seldinger technique using a 0.46-mm diameter nitinol guide wire with a soft platinum tip. Hematoma formation was minimized by proximal digital compression of the vessel after wire placement and during deployment of the catheter. An adequate arterial line waveform was confirmed and the line was secured. After removal of the sterile drape, the skin of the left lower extremity had a patchy looking appearance and felt cold to touch compared with the right side. In addition and in contrast to the right lower extremity, pedal pulses could not be palpated. A continuous infusion of sufentanil was started. The leg was observed for about 15 minutes without noticeable improvement. As further attempts at upper extremity arterial access proved unsuccessful, we decided to place

additional pediatric NIRS probes on each calf of the infant (Figure A). The left calf NIRS value was 44% compared with 94% on the right. Because the CVP had dropped from 9 to 6 mm Hg, whole blood (50 mL) was given empirically, which raised the cerebral and renal but not the left lower extremity NIRS (see Figure B). Low-dose epinephrine ($0.03 \mu\text{g kg}^{-1} \text{min}^{-1}$) and milrinone ($0.5 \mu\text{g kg}^{-1} \text{min}^{-1}$) were started to enhance cardiac output. A papaverine (0.12 mg/mL)-heparin (1 U/mL) infusion was started at 2 mL/h through the femoral arterial line to maintain patency of the catheter and improve limb perfusion. However, no improvement was observed.

During line placement, the patient was under sevoflurane anesthesia and pancuronium for paralysis. His heart rates and blood pressure (systolic/diastolic) varied from 135 to 150 beats/min and 60/30 to 100/55 mm Hg (awake baseline of 80/60 mm Hg). Central venous pressure had decreased from 9 to 6 mm Hg. No discernible hemodynamic changes occurred with the intra-arterial papaverine, which was infused at the recommended rate for arterial lines in infants. The heart rate decreased to 110 to 120 beats/min after starting the sufentanil infusion and remained there during the epinephrine infusion.

We decided to proceed with the cardiac surgery (Figure B) assuming that lower extremity regional oxygenation will improve with initiation of full heparinization and better systemic perfusion on cardiopulmonary bypass (CPB) with the left to right shunt removed. After 15 minutes of CPB during moderate hypothermia (29°C) (Figure C), left calf NIRS values started to increase and reached values $>60\%$ (Figure D). Moderate hypothermia was maintained during the cardiac repair with steady state flows of 0.7 L/min (cardiac index $2.4 \text{ L min}^{-1} \text{ m}^{-2}$), which resulted in mean arterial pressures of 45 mm Hg. CPB duration was 155 minutes, and aortic cross clamp time was 108 minutes. However, the left calf NIRS values remained lower than the right calf values ($\geq 95\%$). During rewarming, left lower extremity values remained in the 60% to 65% range, whereas

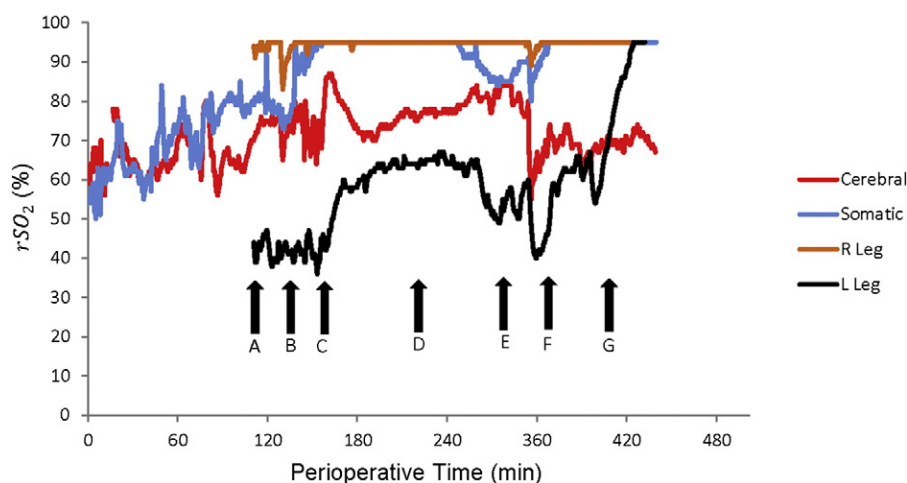


Figure Intraoperative changes in regional oxygen saturation ($r\text{SO}_2$) signals in frontal cerebral, thoracolumbar somatic (renal), and legs (calf) (see text for details).

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