Response of Cerebral Regional Oxygen Saturation (rSO_2) to Changes in Carbon Dioxide (CO_2), as Monitored with the Nonin EQUANOX™ 7600 Regional Oximetry System

EQUANOX™ CASE STUDY

Case Overview

The Nonin EQUANOX 7600 Regional Oximetry System demonstrates a case in which simultaneous monitoring of rSO_2 and $EtCO_2$ helped in preventing cerebral hypoxemia during cardiac surgery on a Down Syndrome infant.

Background:

- *Patient:* 5 month old female, 5.5 kg, 63 cm.
- *Diagnosis:* Down Syndrome, complete atrioventricular canal defect (AV canal), with chief complaint being increased work of breathing (WOB) that was exacerbated during feeding.
- Pre-operative echocardiography revealed a complete atrioventricular septal defect (AVSD), with a moderate sized primum atrial septal defect and a moderate inlet ventricular septal defect. No patent ductus arteriosus (PDA), coarctation, or pleural effusion were noted.
- *Surgical plan:* Complete AV canal repair using a modified single patch technique at moderate hypothermia of 28°C.
- Prior to initiation of Cardiopulmonary Bypass (CPB), the patient experienced multiple episodic changes in the regional oxygen saturation as measured by a cerebral regional oxygen sensor (rSO_2(C)).

Operative Monitoring

The Nonin EQUANOX 7600 Regional Oximeter with EQUANOX™ Model 8004CB Pediatric Regional Oximetry sensors were placed over the frontal cerebral cortex (rSO_2(C)) and flank (rSO_2(S)) for cerebral and renal-bed somatic tissue oxygen saturation monitoring. A Philips IntelliVue® multi-parameter patient monitor was utilized for electrocardiographic, arterial oxygen saturation, end-tidal carbon dioxide ($EtCO_2$), temperatures, non-invasive blood pressure, as well as invasive lines including arterial, central venous, and double lumen placed in the right subclavian vein.

Baseline vital sign monitoring parameters were within normal limits for this patient,[1] as measured by HR-132/minute), RR-37/minute, BP-92/59 mm/Hg and initial rSO_2(C) of 72%. See *Figure 1, Table 1* for pre-bypass vital signs measurements.

What the EQUANOX System Showed

Cerebral rSO_2 monitoring pre-bypass *(Figure 1)* reveals a standard induction pattern of increasing rSO_2 (72 to 91%) prior to induction at 09:41. Following intubation, rSO_2(C) values decrease significantly at 09:46, 10:26, 10:59, and immediately pre-cardiopulmonary bypass at 11:29 to a nadir of 49%. Each of these decreases is followed at varying intervals by increases in cerebral rSO_2. The range of rSO_2(C) values vary from approximately 49-91%.

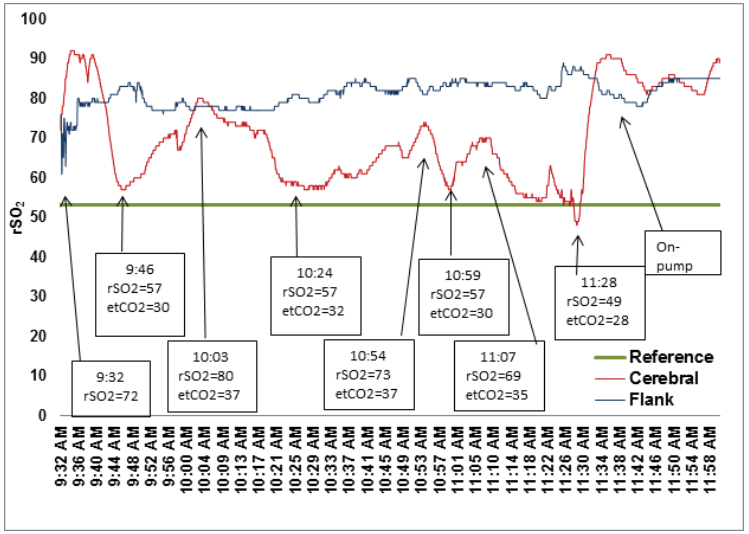

Figure 1: Pre-bypass rSO_2 tracings reveal how the EQUANOX 7600 Regional Oximetry System responded to changes in PCO_2.

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Figure 1, Table 1: Pre-bypass correlating vital sign data

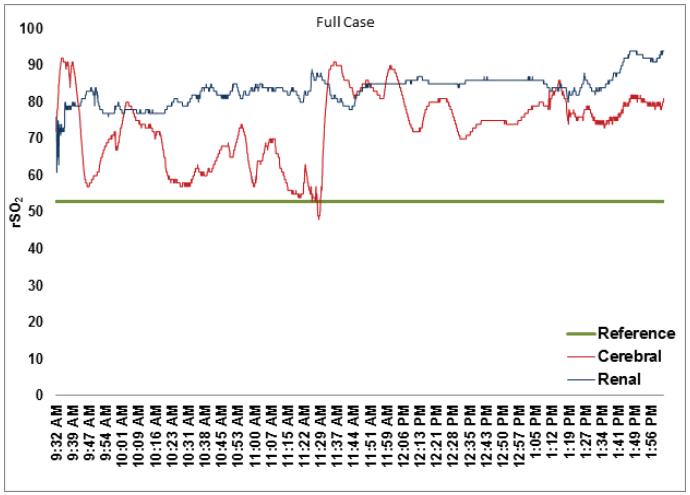
Time	rSO_2(C)	$EtCO_2$	RR	Vt	BP	HR	Event
9:32 AM	72	—	37	—	92/59	132	Baseline
9:37 AM	91	—	—	—	—	—	Induction
9:46 AM	57	30	20	58	90/50	130	
10:03 AM	80	37	16	49	95/53	140	
10:24 AM	57	32	20	49	95/55	142	
10:54 AM	73	37	16	49	95/60	139	
10:59 AM	57	30	20	67	92/49	137	
11:07 AM	69	35	18	67	85/46	140	
11:28 AM	49	28	20	72	80/45	137	
11:34 AM	90	—	—	—	—	—	On-pump

Including $EtCO_2$, minute ventilation in the form of respiratory rate and tidal volume, as well as blood pressure and heart rate information into the rSO_2 tracings *(Figure 2)*, revealed the correlation between minute ventilation, $EtCO_2$, and rSO_2(C). Once established on CPB, all rSO_2 values stabilized and remained within commonly accepted values for the duration of the case *(Figure 2)*.

Discussion

In a New England Journal of Medicine review of the subject of hypocapnea, Laffey and Kavanagh state, "Hypocapnia is neither a benign clinical entity nor an epiphenomenon. On the contrary, hypocapnia appears to induce substantial adverse physiological and medical effects."[1] Indeed, Murkin and Denault identified normalizing PCO_2 as a "top three" interventional technique to reverse cerebral hypoxia in cardiac surgery.[2,3]

Figure 2: Full-case rSO_2 tracing reveals how management of PCO_2 was reflected on the EQUANOX 7600 Regional Oximetry monitor.



Among the physiological effects particular to this case, hypocapnia appears to have contributed to creating cerebral vasoconstriction and reduced tissue oxygen saturation levels in brain tissue. While a reduction in blood pressure may have been a contributing factor to the nadir rSO_2(C) of 49%, the effects of hyperventilation on cerebral perfusion and cerebral oxygen supply are readily discernable utilizing the Nonin 7600 Regional Oximetry System to monitor.

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References:
[1]Kleigman, R.M., et al. Nelson Textbook of Pediatrics. 19th ed. Philadelphia: Saunders, 2011.
[2]Murkin JM et al; Monitoring Brain Oxygen Saturation During Coronary Bypass Surgery: A Randomized, Prospective Study; Anesthesia & Analgesia, Vol 104, No 1, Jan 2007.
[3]Denault A et al; A Proposed Algorithm for the Intraoperative Use of Cerebral Near-Infrared Spectroscopy; Semin Cardiothorac Vasc Anesth 2007; 11; 274.

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