Postoperative cerebral oximetry monitoring helps in early detection of diminished flow in Blalock–Taussig shunt

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ABSTRACT

Cerebral oximeter is a noninvasive device which provides continuous monitoring of the regional cerebral saturation using near-infrared spectroscopy (NIRS). After gaining popularity as an intraoperative monitoring tool, use of NIRS monitoring has also expanded to postoperative period of congenital heart diseases now. Shunt underflow is a known complication after Blalock–Taussig (BT) shunt, which is conventionally detected by a drop in oxygen saturation and metabolic acidosis. We report a case where cerebral regional saturation monitoring by NIRS helped in early detection of low pulmonary flow state during postoperative period of neonatal BT shunt. We observed that the drop in regional cerebral oxygen saturation preceded fall in peripheral oxygen saturation during shunt underflow.

Keywords: Blalock–Taussig shunt, cerebral oximetry, near-infrared spectroscopy, postoperative care

INTRODUCTION

Cerebral oximeter is a noninvasive device which provides continuous monitoring of the regional cerebral oxygen saturation (rSO_2) using near-infrared spectroscopy (NIRS). Apart from intraoperative monitoring during cardiac surgery, this monitor is now being used in diverse clinical fields including neurosurgery and vascular surgery.[1] Of late, the use of this monitor has also expanded to postoperative period of congenital heart diseases, mainly as a tool to monitor cerebral oxygenation. Here, we report a case where NIRS monitoring during postoperative period of Blalock–Taussig (BT) shunt helped in an unintended way. In our case, rSO_2 monitoring by NIRS helped in early detection of low pulmonary flow state during immediate postoperative period of neonatal BT shunt.

CASE REPORT

A 3.2 kg term baby presented with central cyanosis soon after birth (peripheral oxygen saturation [SpO_2] – 55% on room air). Prostaglandin E1 infusion at a dose of 0.05 μg/kg/min was started with suspicion of duct-dependent congenital cyanotic heart disease, before transferring to our center. On admission to our center, SpO_2 had improved to 92%. Echocardiography showed pulmonary atresia, ventricular septal defect, and patent ductus arteriosus supplying branch pulmonary arteries. On day 3 of birth, the child underwent palliative modified BT shunt with anastomosis between innominate artery and right pulmonary artery using a 4-mm graft. Intraoperatively, cerebral rSO_2 was monitored using bilateral frontal NIRS sensors (SenSmart, NONIN). SpO_2 improved to 95% after BT shunt, and prostaglandin infusion was discontinued soon after the surgery. The child was shifted to pediatric cardiac intensive care unit (PCS ICU) with the same cerebral oximeter probes and monitor.

Vital parameters at the time of admission in PCS ICU were as follows: heart rate 150/min, blood pressure 72/42/52 mmHg, and Spo_2 88% on pressure control mode

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ventilation (Ppeak – 15, PEEP – 5, and FiO_2 – 1). Baseline cerebral rSO_2 in ICU was 72% and 75% in the right and left, respectively. Patient was maintaining hemodynamics without any inotropes. Initial arterial blood gas showed mild metabolic acidosis (pH – 7.31/PO_2 – 67 mmHg/PCO_2 – 39 mmHg/HCO_3 – 22). Urine output in 1st h was 1 ml/kg/h, and central venous pressure (CVP) values were between 7 and 8 mmHg. At 1 h, a drop in rSO_2 63% and 50% on the left and right, respectively, was observed with a marginal drop in SpO_2 86%. The child was optimally sedated with fentanyl infusion, and there was no significant change in blood pressure (70/40/50 mmHg) or CVP during the onset of this event. Hemoglobin value was 12.1 g/dl and chest X-ray done postoperatively also had shown normal lung fields. A fall in SpO_2 50% occurred 90 s after the fall in rSO_2 and auscultation revealed faint shunt murmur. Transthoracic echocardiography showed minimal flow through the BT shunt and good biventricular function (ejection fraction – 50%). A shunt blockage was anticipated, and fluid bolus of normal saline 10 ml/kg and a heparin bolus of 50 IU/kg were given. Manual hyperventilation was started to induce respiratory alkalosis. After these interventions, rSO_2 and SpO_2 improved to their first baseline values. We suspected high pulmonary vascular resistance as the causative factor for decreased pulmonary blood flow. Norepinephrine was started at a dosage of 0.1 μg/kg/min to increase systemic to pulmonary driving pressure. Heparin infusion at 10 IU/kg/h was also initiated simultaneously to prevent clot formation secondary to sluggish flow across shunt. Two more similar episodes of drop in rSO_2 (>20% drop from baseline) and SpO_2 occurred at 6 h and 7 h postoperative period as shown in Figure 1. During each episode, drop in rSO_2 preceded the drop in SpO_2. Both these episodes responded to measures to decrease pulmonary vascular resistance. Intravenous infusion of sildenafil was started to reduce the high and reactive pulmonary vascular resistance of the neonatal pulmonary vasculature. Follow-up two-dimensional echo done at 18 h showed adequate flow through the BT shunt and absence of flow through the ductus arteriosus.

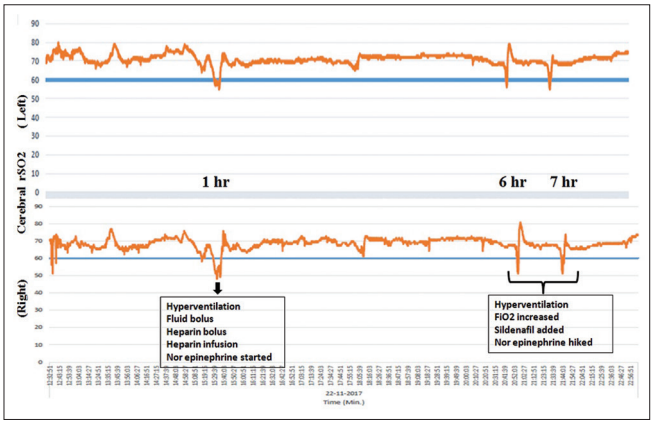

Figure 1: Regional cerebral oxygen saturation records by near-infrared spectroscopy during first 12 h postoperative period. There was fall in regional cerebral oxygen saturation on both sides at 1, 6, and 7 h postoperative period. Interventions done during fall in regional cerebral oxygen saturation are given in the boxes

Norepinephrine was tapered gradually and stopped. The cerebral NIRS monitoring was continued for 3 days during which rSO_2 recordings did not show significant change. The child was successfully extubated on day 3 and discharged on day 6 of hospital stay.

DISCUSSION

NIRS measures the average oxygen saturation of hemoglobin in small "gas-exchanging" vessels in the tissue and is based on the balance between cerebral oxygen delivery and consumption.[2] Beyond providing continuous insight into regional oxygenation of the brain, cerebral oximetry may allow clinicians to use the brain as an index organ that points to the adequacy of tissue perfusion and oxygenation of other vital organs.[3]

Modified BT shunt is commonly done as a palliative procedure for a variety of congenital cyanotic heart diseases. It is associated with significant mortality, ranging from 2.3% to 16% as in different studies.[4] Low body weight, small shunt size, overshunting, and univentricular hearts have been identified as risk factors associated with mortality. Inadequate flow through BT shunt and shunt overflow are known complications in the postoperative period. Shunt underflow is conventionally detected by a drop in SpO_2 and metabolic acidosis. In our case, we observed that cerebral rSO_2 dropped before SpO_2 and it helped us in early detection of diminished shunt flow. Rossi *et al.* had previously reported a case in which cerebral oximeter was the first monitor to alert a diminished flow during noncardiac surgery in a patient with preexisting shunt.[5] Tobias observed that cerebral oximetry monitoring with NIRS detected alterations in oxygenation before pulse oximetry during paralytic agent-induced apnea for airway laser surgery.[6] High degree of oxygen extraction in the brain relative to other organs could be responsible for this early fall in rSO_2 when oxygen delivery decreases. The baseline value of partial pressure of oxygen in tissue is low compared to arteries (PaO_2). It reaches the bend of the oxy-Hb dissociation curve more quickly compared to PaO_2, and hence, a minimal fall in partial pressure of oxygen value will be reflected as change in saturation at tissue level.

However, validation of NIRS is challenging and clinicians must proceed with caution before using this sole data point as a decision-making tool. Schwartz *et al.* monitored NIRS during BT shunt procedure and

noticed two precipitous declines in cerebral rSO_2, first during shunt underflow and second during pulmonary overflow leading to systemic steal.[7] Hence, though not specific, a low rSO2 level is an alarm that needs to be analyzed and compared with other parameters to take appropriate measures. As it can give early clue about both pulmonary underflow and overflow, apart from its primary function as a neurological monitor, we feel that cerebral oximetry monitoring postoperatively in children undergoing BT shunt might be beneficial. This might be more important in neonatal population, who are inherently at risk of adverse cerebral events and shunt underflow.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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