Anesthetic Management of Premature Neonate for Open Abdominal Surgery

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Introduction

Premature neonates often have congenital disorders and underdeveloped physiology that make them more prone to morbidity and mortality in the perioperative period. Specifically, patients born prior to surfactant development in the lungs (35-36 weeks gestational age (GA) have problems with maintaining ventilation and oxygenation, leading to ventilator dependence in the NICU, which can in turn cause weakened lung tissue via atelectrauma and cause respiratory issues later in life.[1] Commonly, premature patients have congenital heart defects that can require intervention and careful management in the perioperative period to maintain appropriate oxygenation and circulation status.

Healthy patients of any age maintain a core temperature in a narrow range ~~of~~ around 37 deg C. Neonates rely on non-shivering thermogenesis (NST), or brown-fat-dependent lipolysis, to regulate their central temperature as their muscles are immature at this stage of life. Brown fat is deposited throughout the body after 28 weeks gestation in utero, and babies born earlier have limited ability to regulate temperature due to the lack of appropriate tissue[2,7]. These patients experience a notable amount of radiant heat loss via their head due to the large surface area and lack of insulating hair and tissue. In addition, a neonate can experience heat loss to the environment, contact with the OR table and tools, and vapor loss to the surrounding air[2].

Patients maintained on inotropes, mechanical ventilation, born at or before 24 weeks GA, female sex, and/or at an ASA class of 3 or higher are significantly associated with 30-day mortality following emergency abdominal surgery[5]. Respiratory events including laryngospasm, apnea of prematurity, upper airway obstruction, and post-intubation stridor are most commonly linked to perioperative mortality in the neonate population[5]. This case highlights multiple common physiologic challenges when managing a neonate in the OR and the difficulty of maintaining appropriate core body temperatures in an unregulated individual.

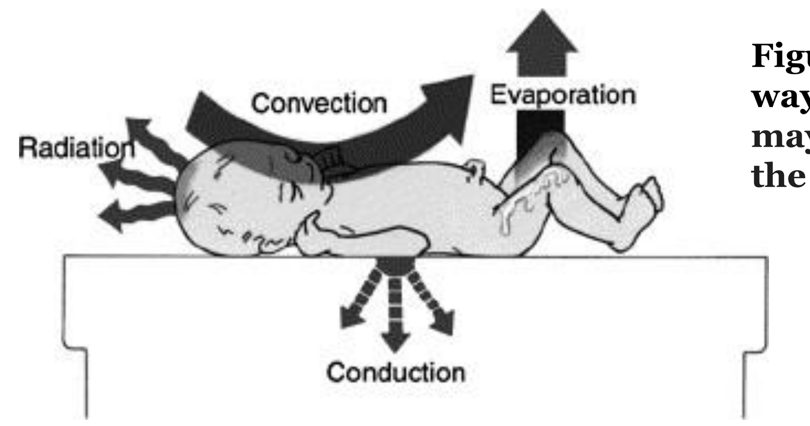

Figure 1. Four ways a newborn may lose heat to the environment.[2]

Learning Objectives

1. Explore the general concerns of neonates undergoing abdominal surgery.
2. Understand the management of patients with congenital heart deformities (i.e. PDA, PFO).
3. Discuss pulmonary complications of neonates with limited surfactant availability and lung development.
4. Examine the importance and common practices of temperature management in pediatric patients.

Case Significance

As medicine advances, preterm infants can receive better treatment~~,~~ and progress into childhood and beyond. Challenges faced in this case included the management of acyanotic shunts, maintaining proper oxygenation and ventilation on a non-NICU-equipped ventilator with premature lung tissue, and optimizing the patient's core temperature.

The primary goals of managing acyanotic shunts are to prevent increasing pulmonary vascular resistance (PVR) while decreasing systemic vascular resistance (SVR) and myocardial dysfunction.[5] Similarly, bronchopulmonary dysplasia (BPD) is managed perioperatively by using lung-protective ventilation and reducing over circulation of the pulmonary system by controlling patent ductus arteriosus (PDA) hemodynamically.[1] The management of cardiac shunts and immature lungs both involve a steady balance between oxygen optimization, ventilation, and pulmonary blood pressures of the patient. Neonates of any GA have a reduced capacity to regulate central temperature changes, making it crucial for the provider to actively warm the patient. Hypothermia in neonates eventually leads to hypoxemia, hypoglycemia, acidosis, and right-to-left shunting via pulmonary vasoconstriction. This can result in sepsis, decreased healing, arrhythmias, increased risk of infection, and poor neurological outcomes[8].

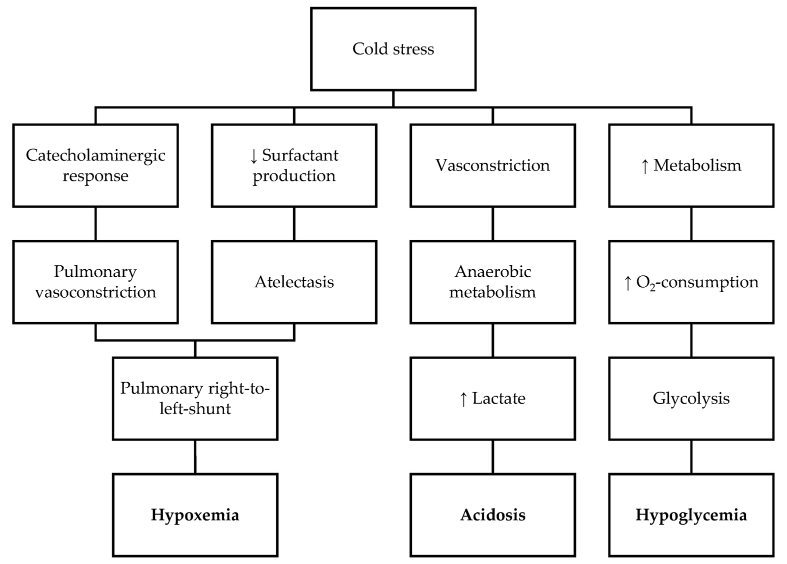

Figure 2. Pathophysiological pathways resulting from adverse events induced by cold stress in neonates.[8]

Patient Description

A 17-day old, ex-24 wk GA male (0.835 kg), ASA 4, presents for an exploratory laparotomy with hemicolectomy, drainage of abdominal abscess, appendectomy, and illeumectomy due to presence of pneumoperitoneum from perforated bowel. Patient has PDA and PFO treated with IV Acetaminophen, apnea of prematurity treated with caffeine infusion, developing BPD, and a holosystolic murmur on auscultation. He is intubated and on continuous supported ventilation of 15/5 cmH2o PIP/PEEP, 10 cmH2O PS at FiO2 23% with V_T of 6 mL in NICU. PICC line, 24G PIV, and OG in place already. On presentation to the OR, patient is on continuous infusions of fat emulsion 3 g/kg, TPN, IV Acetaminophen, 15 mg/kg q6 hr, and caffeine citrate 8 mg/kg q 24 hr. Orders for 25 mL PRBCs to begin in the OR are completed in the perioperative period. All vital signs were within normal range for age and premature status upon arrival to OR.

Anesthetic Intervention

- The patient arrived to the perioperative holding area in an isolette with a transport ventilator from the NICU bay where the anesthesia team took over care and was transported to the OR with all lines and continued infusions in place.
- The OR was preheated to 30˚C, a pediatric-sized underbody Bair Hugger was running at 43˚C on the OR table, and the radiant warmer was turned to the maximum intensity on the area of the bed that the patient would be positioned. These measures were continued throughout the procedure with the exception of the radiant warmer being removed for continuity of sterility. The surgical team had prewarmed irrigation fluid available for the case.
- The patient was disconnected from the transport ventilator, positioned on the OR table on top of the Bair hugger, and reconnected to the anesthesia machine ventilator. He maintained 100% SpO2 and stable vital signs throughout the transition.
- All ASA monitors were switched from the isolette transport monitor to the anesthesia machine and a temperature probe was placed in the patient's esophagus for the duration of the operation. The patient's head continued to be covered by a knitted hat to minimize heat loss from the large surface area.
- Induction of anesthesia with sevoflurane at FiO2 of 49%, 2 mg rocuronium, and 10 mcg fentanyl for ~~proper~~ pain control and paralysis. FiO2 continued at 30% for the remainder of the procedure. When the patient was ready for transport back to the isolette, the FiO2 was increased to 100% for optimal oxygenation before ventilator reconnection.
- Ventilation of patient remained at set parameters from NICU (PIP/PEEP 15/5 cmH_2O, TV 6 mL) on PCV via anesthesia ventilator. Pressure support parameters were avoided due to interference from the operative area. $ETCO_2$ remained within the normal range (35-40 mmHg) throughout the case.
- Transfusion of 25 mL (30mL/kg) PRBCs started as ordered by the NICU team for mitigation of blood loss and correction of anemia present in most preterm neonates[3]. This was not given through a warmer, assuming a temperature of less than 20 deg C (room temperature)[4] as it was cold to the touch from storage.
- Vitals remained stable and constant through the perioperative period, yet core body temperature gradually decreased to 33.2 deg C (see Figure 3).

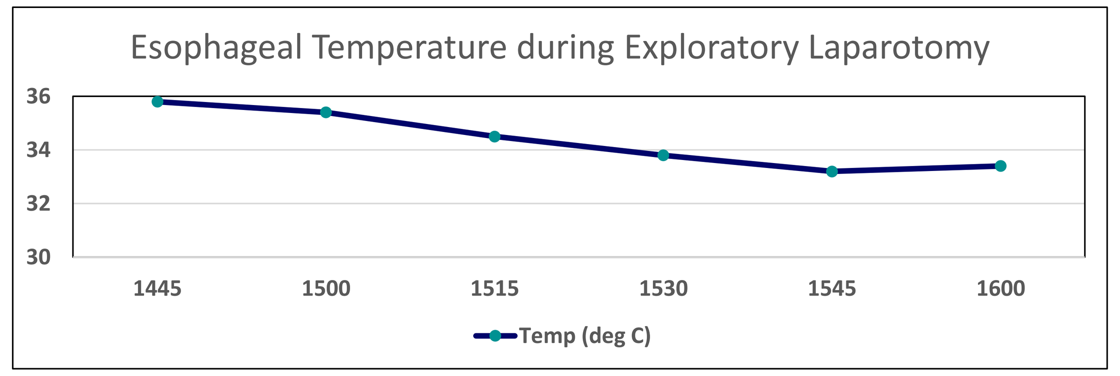

Figure 3. Esophageal temperature (˚C) during open abdominal case of 17 day old premature male

- Upon the end of the operation, irrigation was pooled around the patient's abdomen, chest, and extremities. Despite the use of prewarmed irrigation, it did not remain warm as it pooled on the OR table.
- The radiant warmer was returned to the bedside and warm blankets covered the body and head to rewarm the patient before transport back to NICU. The Isolette was prewarmed to 38˚C before moving the patient back. Rewarming attempts continued for approximately 15 minutes before leaving the OR, at which point the patient's core temperature had only reached 34 ˚C.

Discussion and Conclusion

Neonates born before a GA conducive to life without invasive support require closer management than the typical patient. This 17-day-old, 24-week GA male required intervention to comply with his existing PDA, PFO, poor lung development, and inability to regulate his temperature.

The acyanotic left-to-right shunting in his cardiovascular system was being treated with a 15 mg/kg IV Acetaminophen infusion per NICU team orders. Higher pressures in the aorta than the PA allow blood flow through the PDA resulting in higher pulmonary blood circulation, pulmonary artery (PA) overload, elevated left heart filling and pressures. Higher left atrial pressure than right atrial pressure allows blood flow through the PFO which is typically asymptomatic. This patient's holosystolic murmur suggests a moderately sized PFO[8] which similarly overloads the PA and left heart. To prevent the worsening of the PDA and PFO, the primary goals were to avoid increasing PVR via hypoxia, hypercarbia, acidosis, pain, and elevated PEEP[8,9].

Managing the patient's immature lungs simply required the continuity of controlled ventilation from NICU protocol. Basic ventilator settings were maintained from NICU parameters to avoid unnecessary volutrauma or barotrauma. A slightly higher FiO_2 of 30%– as opposed to 23% in the NICU– was used intraoperatively to maintain 100% SpO_2 on a non-NICU-equipped ventilator. A relatively higher FiO_2 in preterm neonates can cause hyperoxia-induced changes in the immature vasculature and alveoli[1]. The transport and anesthesia ventilators have less precision than ICU ventilators, so the slightly higher FiO_2 allowed for the variation. The patient's $ETCO_2$ remained within normal limits (35-40 mmHg), avoiding the presence of hypercarbia. Transfer of the patient from the NICU to the OR and back required a minimum of four ventilator changes. The use of less precise ventilators for a prolonged duration can compromise oxygenation in a heart rate-dependent patient during the transition, leading to unnecessary lung tissue stress. Open abdominal surgeries have been performed in the NICU safely in similarly equipped hospitals, which would have aided in reducing the risk of extubation, improper monitoring, and ventilatory throughout the patient's entire perioperative experience[6].

The primary issue of the case was temperature management in this patient. Our anesthesia and OR teams took every prophylactic measure available to us at the time to preheat the environment and maintain core body temperature. Between the prewarmed irrigation fluid pooling around the bulk of the body and the administration of 25 mL of cold PRBCs amounting to roughly 1/3 of the EBV (835 mL), the core body temperature dropped 3˚C and the patient was relatively resistant to reheating from the return of the radiant warmer and warm blankets. The patient only started to more rapidly rewarm when placed in the Isolette set to 38 deg C for transport. Radiation is recognized as the best form of patient warming, and the most abundant type of heat loss[8]. As suggested in *Neonatal Thermogenesis*, moderate hypothermia can be treated by a warm cot, incubator, radiant warmer, warm room, warm water-filled mattress, or finally skin-to-skin contact[8]. In cases with similarly incapacitated patients, efforts should be made to warm the OR to the suggested 32 dec C[8] and transition the patient to the Isolette warming device as soon as safely possible. If the surgery and sterile field allow, it would be advantageous of the surgical team to keep fluids from surrounding the patient. Warming the PRBCs even to room temperature, if not having them run slowly through a fluid warmer with a continuous crystalloid infusion would prevent the temperature from dropping, if not warm the patient more. Finally, the administration of such a large dose of opioids (10 mcg fentanyl– 12 mcg/kg) contributed to the hypothermic response seen in this patient. The activation of kappa opioid receptors via nitric oxide second messengers is directly correlated to lower core temperatures in patients receiving relatively large opioid doseages[10]. This case illustrates that temperature management in pre-term neonates is multifaceted, and merits significant consideration when developing an anesthetic plan for patient care and perioperative management.

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