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Case Series

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Extremely low birth weight (ELBW) neonates for emergency surgery- A challenge for the Anesthesiologist: A case series

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ABSTRACT

Background: Extremely Low Birth Weight (ELBW) newborns, defined as those with a birth weight of 1000 grams or less, present challenging anesthetic scenarios. Emergency surgeries in these infants elevate their vulnerability to various complications.

Case Presentation: We present a case series involving 5 ELBW neonates who underwent emergency surgery. Three of them were at a post-conceptual age (PCA) of ≥ 33 weeks and underwent procedures for congenital birth defects, including esophageal atresia, ileal atresia, and gastroschisis. The remaining two neonates, with a PCA of 29-30 weeks, underwent surgery for necrotizing enterocolitis (NEC).

Conclusion: The compromised physiology resulting from distinct disease processes and the underdeveloped systems of ELBW preterm neonates necessitate focused care and strategic anesthesia. This approach is crucial to mitigate morbidity and mortality risks in such vulnerable patients.

INTRODUCTION

The perioperative management of neonates poses a considerable challenge, even for seasoned anesthesiologists. In the case of extremely low birth weight (ELBW) neonates, issues associated with prematurity, such as broncho-pulmonary dysplasia, further contribute to the complexity of management [1]. The immature physiological adaptation demands heightened vigilance for the rapid detection and correction of hypothermia, hypoglycemia, fluid and electrolyte imbalances, and infection. A favorable postoperative outcome hinges on the anesthesiologist's comprehensive understanding of neonatal and transitional physiology, coupled with skillful handling. In this context, we present a case series involving 5 ELBW neonates, highlighting the anesthesia challenges encountered during their surgeries.

CASE SERIES

We report 5 ELBW neonates (NN) who underwent emergency surgery over a period of one year from January 2022 to December 2022. Three of them were ≥ 33 weeks post-conceptual age (PCA) while the other two were 29-30 weeks PCA. All the neonates were inborn in the hospital and were admitted in the Neonatal Intensive Care Unit (NICU). Details of all the five neonates are summarized in Table 1.

A thorough preoperative history including antenatal history, gestational age, weight, any comorbidity such as birth asphyxia, meconium aspiration, seizure and requirement of oxygen therapy was taken. Neonates with endotracheal tube (NN-1 & 3) were auscultated to check the appropriate placement of endotracheal tube. Rate of inotropic infusion and their concentration were noted (NN-1 & 2). Recent blood investigations including complete blood count, coagulation profile, serum electrolytes, glucose level were checked. Cross match blood was kept available for transfusion if required. Written informed consent was taken from the parents for general anesthesia, any invasive procedure, blood transfusion or postoperative ventilation.

All equipment including the anesthesia machine, ventilator, breathing circuits and infusion pumps were pre checked. Electrical supply and battery backup for infusion pumps were assured. Oropharyngeal airway (000-00), endotracheal tube (2 to 3.5 mm), stylet, conventional laryngoscope with a straight blade of the right size, video-laryngoscope (C-MAC with blade 0,1) and laryngeal mask airway (LMA)

of smallest size were kept ready. The operating room (OR) was pre-warmed, and so were the intravenous (IV) fluids. Warming mattress on the operative table and forced air warmer were also switched on.

Table 1: Details of ELBW surgical neonates

S. No	Post-conceptual age (PCA)	Day of life at which surgery was done	Weight	Diagnosis and surgical procedure	Preoperative Status	Duration of Surgery	Final outcome
1.	33 Weeks + 1 Day	Day 2, operated early due to rapid deterioration	800 gm	Esophageal atresia-esophagostomy and gastrostomy	Received Intubated from NICU on inotropic support	120 min	Died on 2nd POD
2.	30 Weeks	Day 8	800 gm	NEC (Bell's stage 3)- laparotomy with resection of gangrenous bowel and colostomy	O2 by Hood, inotropic support	60 min	Extubated after 48 hours of surgery & discharged on oral feed on 20th POD
3.	29 Weeks + 3 Days	Day 3	700 gm	NEC (Bell's stage 3)- laparotomy with resection of gangrenous bowel and ileostomy	Received Intubated from NICU, high oxygen requirement	90 min, started on inotropic support intra-operatively	Died on 3rd POD
4.	35 Weeks + 5 Days	Day 1	900 gm	Ileal Atresia-resection of atretic bowel with end to end anastomosis	O_2 by nasal prongs @ 2 L/ min	60 min	Extubated after 24 hours of surgery & discharged on 10th POD
5.	35 Weeks + 1 Day (Fig 1)	Day 1	900 gm	Gastroschisis-repair of defect and primary abdominal closure	O_2 by hood	60 min	Extubated after 24 hrs of surgery and discharged on 15th POD

(O2- Oxygen; NICU- Neonatal intensive care unit; POD- Postoperative day; NEC- Necrotising enterocolitis)

As these neonates were already admitted in neonatal intensive care unit (NICU), IV access through the umbilical vein and 24G cannula was in-situ, their patency was confirmed in the OR. Glucose-containing fluids were kept ready. All exposed non-involved areas were covered by cotton or any other protective wrapping. Routine monitors including electrocardiogram (ECG) using neonatal electrodes, precordial stethoscope, temperature probe, capnography, non-invasive arterial pressure with appropriate size cuff were applied. Two pulse oximeter probes were used, one probe was placed on the right hand (preductal) and another on a lower limb (post ductal). Urine output was monitored throughout the surgery.

General anesthesia was administered using intravenous injections of fentanyl, thiopentone and atracurium according to body weight. Appropriate size endotracheal tube was placed to secure the airway. Maintenance of anesthesia was done using oxygen, nitrous oxide, sevoflurane (1.5- 2%) and intermittent atracurium. Fluid and blood were replaced as per loss and requirement. Inotropic support (dopamine) was continued to maintain adequate blood pressure (NN 1, 2 & 3). Oxygen concentration was adjusted to maintain the SpO2 of 87-94% while avoiding 100% oxygen. Heart rate varied between 130-150 beats/min. Random blood sugar was checked perioperatively and euglycemia was maintained using background infusion of the glucose containing fluid. Body temperature was maintained between 36–37oC. Post-operative pain relief was achieved by intravenous injection of paracetamol and local infiltration of the surgical wound.

Keeping in mind the possibility of postoperative apnea, all 5 neonates were not extubated after surgery and were electively ventilated. The postoperative outcome is summarized in Table-1.

DISCUSSION

Neonates with a birth weight of less than 1000 gm, regardless of gestational age, fall into the category of extremely low birth weight neonates (ELBW). These neonates are predominantly premature, with an

incidence ranging from 4-16% [2]. Due to the anatomical and physiological immaturity of their organs, they encounter challenges in adapting to extrauterine life. The survival rate decreases with decreasing neonatal weight, with rates of 90% for those weighing 800-1000 gm and 75-85% for those weighing 600-800 gm [3].

Emergency surgery in premature ELBW neonates heightens their susceptibility to complications such as respiratory distress syndrome, intraventricular hemorrhage, and sepsis, leading to an increased mortality rate. Poor preoperative status and prolonged surgical times further contribute to unfavorable outcomes. Additionally, the nature of the congenital defects or pathological conditions for which emergency surgery is performed plays a crucial role.

In our first neonate, who had esophageal atresia (EA), a relatively common congenital anomaly occurring in 1:3000-4500 live births and may be associated with cardiac anomalies [4], preoperative optimization was crucial. This patient had sepsis, severe aspiration pneumonia, and required inotropic support preoperatively. Ideally, conservative management involving elective ventilation and monitoring the response to antibiotics should have been pursued. However, due to the rapidly deteriorating condition, early surgery was performed on the second day of life. The poor preoperative condition, including ventilatory support and inotropic requirements, coupled with a prolonged duration of surgery, may have contributed to an unfavorable postoperative outcome for this neonate.

Necrotizing enterocolitis (NEC) demonstrates a direct correlation with decreasing gestational age, with an incidence of 7% in premature neonates and a mortality rate of approximately 50% in extremely low birth weight (ELBW) neonates [5]. These critically ill neonates present with abdominal distension, hypotension, coagulopathy, sepsis, dehydration, and electrolyte imbalance, necessitating careful fluid management to address dehydration.

NN-2 and NN-3, with nearly the same weight and gestational age at birth, underwent surgery for NEC. NN-2, operated on day eight of life, exhibited a better preoperative condition compared to NN-3, who was operated on day three of life. NN-3 had rapidly developing NEC, a poor preoperative status (including compromised chest condition with high ventilatory support), initiated inotropic support intraoperatively, and underwent a prolonged surgical procedure (90 min). NN-3 also had the lowest weight among all five neonates, measuring 700 gm.

Joshi et al. [6] successfully managed an ELBW neonate (29 weeks, 840 gm at birth) with hyaline membrane disease, pneumonia, hemolytic jaundice, septicemia, and intraventricular hemorrhage. The neonate underwent two surgeries for NEC at day 13 and day 20 of life. The operating team, in this case, waited for the general condition to improve and for septic shock to resolve before proceeding with surgical management. Williams et al. [7] reported a case of an ELBW neonate (31 weeks + 4 days, 913 gm at birth) who underwent NEC surgery on day four of life without preoperative oxygen or inotropic requirement. This neonate was successfully managed in the NICU with elective postoperative ventilation, weaned off successfully, and discharged from the hospital.

Our 4th neonate had ileal atresia, diagnosed prenatally using USG. The associated conditions such as cardiac anomaly, gastroschisis or cystic fibrosis were already ruled out [8]. This NN was relatively stable, born at 35th week with weight of 900 gms. Duration of surgery was limited (<1hr) and the postoperative outcome was good. The neonate with gastroschisis (NN-5) was also stable with a gestational age of 35 weeks (late preterm), higher weight (900gms) than rest of the neonates and limited duration of surgery (<1hr) leading to a good postoperative outcome.

There are various concerns during anesthesia for ELBW neonates for which adequate measures should be taken. Intravenous cannulation is difficult and requires expertise to establish 24/26 G cannula. Umbilical vein cannulation is a safe and easy alternative. Strict asepsis is emphasized to prevent infection. Protein based or hydrocolloid transparent adhesives should be used for fixation of intravenous cannula or endotracheal tube, to prevent epidermal stripping and erythema associated with removal of adhesive tapes [9]. In contrast to the term neonates, a small drug dosage is required as their effect lasts longer due to low clearance and longer half-life. Inhalational induction is faster due to high cardiac output and respiratory rate and higher doses of inhalational agents may lead to myocardial depression.

These neonates may require smaller/ uncuffed endotracheal tubes. Cuff pressure should be monitored if a cuffed tracheal tube is used. Dead space should be minimized and care should be taken while using ventilators as they have immature lungs and lack of surfactant leading to barotrauma during positive pressure ventilation [1]. Target SpO2 should be kept in the range of 87-94%. High oxygen concentration can cause bronchopulmonary dysplasia, retinopathy of prematurity and neurodevelopmental anomaly. Hypoxia should also be avoided as it has detrimental effect on pulmonary

vascular pressures and may also affect immature neurons leading to periventricular leukomalacia [10].

ELBW premature neonates are more prone to develop hypothermia due to high body surface to body weight ratio, decreased brown fat store, non-keratinized skin with decreased glycogen stores [1]. Preventive measures should be taken perioperatively by ensuring a working warming mattress, warm intravenous fluids and warm irrigation fluids used by surgeons as well as covering the child. Temperature monitoring is essential. Smaller size BP cuff should be available for non-invasive BP monitoring. Invasive BP monitoring is more accurate, as it gives beat to beat variation. Also, it is helpful in preterm ELBW neonates due to lower autoregulatory limit of cerebral circulation [8]. Adequate distal perfusion is to be ensured if an arterial line is placed.

Cardiovascular collapse is more likely due to blunting of baroreceptor reflex, limited ventricular capacity, higher heart rate, low blood volume and underdeveloped autoregulation [1]. Close vital monitoring is essential throughout the surgery. Hypoxia, acidosis, hypercarbia and hypothermia can cause pulmonary hypertension which can cause return to fetal circulation. They have compromised renal function due to decreased glomerular filtration rate (GFR) and immature renal tubular function hence fluid overload or deficit should be corrected as per requirement. Third space losses should be considered and replaced adequately. Premature ELBW neonates are also prone to develop hyponatremia, hyperkalemia, hypocalcemia and hypomagnesemia, therefore, electrolyte balance is to be maintained taking special care during blood transfusion. ELBW neonates are prone to develop hypoglycemia, to prevent which dextrose should be supplemented. Blood glucose level should be kept in the range of 70-150 mg/dL. Hyperglycemia should also be avoided as it can cause intraventricular hemorrhage & osmotic diuresis [11].

Adequate intraoperative and postoperative analgesia should be ensured to prevent the occurrence of intraventricular hemorrhage and periventricular leukomalacia which may progress to cerebral palsy later. Hypovolemia and septic neonates are more prone to develop these complications. Postoperative apnea is very common in ELBW premature neonates especially with anemia and sepsis. Postoperative elective ventilation is recommended. Preoperative administration of 5-10 mg/kg of caffeine significantly reduces the post-operative apnea as it stimulates respiratory as well as cardiovascular system [1, 12]. Vital monitoring, temperature maintenance and continuation of inotropic infusion during transportation from neonatal intensive care unit (NICU) to OR and from OR to NICU are most important, as in this transition time complications like cardiovascular collapse, hypothermia, displacement of intravenous cannula or endotracheal tube can occur.

In Spite of taking all the above precautions, two of our neonates (NN-1 & 3) had unfavorable outcomes. Both these neonates were in septicemia, had poor preoperative general condition with requirement of ventilatory support. NN-1 was already in septic shock preoperatively, while NN-3 required inotropic support intraoperatively which was continued in the postoperative period. Moreover, the duration of surgery was also longer in these neonates, contributing further to the cause of adverse outcome. Initial conservative management and preoperative optimization of these neonates with a limited operative time could have resulted in a better postoperative course.

The compromised physiology resulting from unique disease processes and underdeveloped systems in a preterm extremely low birth weight (ELBW) neonate demands a comprehensive understanding, meticulous planning, and thorough preparation for the administration of anesthesia. This approach is essential to prevent drastic complications and ensure favorable outcomes for such neonates. Effective teamwork and coordination among the Anesthetist, Pediatric surgeon, and Neonatologist are crucial for both preoperative optimization and postoperative care

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