The Heart Surgery Forum 2021-4499
25 (2), 2022 [Epub April 2022]
doi: 10.1532/hsf.4499

Online address: http://journal.hsforum.com

Anesthesia Management of a Premature Neonate with Congenital Heart Disease during Emergency Diaphragmatic Hernia Surgery: A Case Report

Zhang Fan,[1] Zheng Zebing,[2] Gong Taowu,[1] Zhu Zhaoqiong[1]

[1]Department of Anesthesiology, Affiliated Hospital of Zunyi Medical University, Zunyi, Guizhou, China;
[2]Department of Pediatric and Neonatal Surgery, Affiliated Hospital of Zunyi Medical University, Zunyi, Guizhou, China

ABSTRACT

In this medical report, we successfully implemented anesthesia management for an infant with congenital heart disease undergoing congenital diaphragmatic hernia (CDH) repair. Left-sided CDH was diagnosed on a postnatal chest X-ray on day 1 of her life. The child was complicated with congenital heart diseases and pulmonary hypertension and showed severe dyspnea immediately after birth. Thoracoscopic CDH repair puts forward high requirements for anesthesia. Neonatal CDH combined with congenital heart disease brings more challenges to anesthesia. For high-risk premature neonates, anesthesia selections are essential, as those factors directly affect the prognosis. We report the application of S-ketamine as an anesthetic in this kind of operation for the first time. The postoperative recovery was uneventful. This case report reviews anesthesia management of critical CDH neonates, hoping to provide information to healthcare professionals unfamiliar with the treatment of this kind of patient.

INTRODUCTION

Congenital diaphragmatic hernia (CDH) is a congenital malformation in which abdominal organs enter the thoracic cavity due to unilateral or bilateral diaphragmatic development defects. CDH is one of the primary diseases leading to neonatal perioperative death. Surgical treatment often is urgently needed for severe conditions within 1 ~ 2 days [Goonasekera 2016]. With the improvement of anesthesia technology and the emergence of new anesthetic drugs, the anesthetic mortality of CDH has decreased significantly. However, challenges still arise in critically ill neonates. Few CDH anesthesia management case reports exist [Testini 2017], and of those, even fewer are related to neonates [Choudhry 2021]. Our hospital handled a patient in critical condition, as reported below. We reported the article, in accordance with the CARE reporting checklist.

CASE REPORT

A 5 h female newborn was admitted into the Department of Neonatal Pediatrics for "shortness of breath, cyanosis for 5 h, aggravation for 1 h." The neonate was born at a gestational age of 36 weeks by cesarean section; she weighed 2,780 g. Apgar's scores at birth were 8, 9, and 9 at 1, 5, and 10 minutes, respectively. With the exacerbation of hypoxia, the neonatologists gave her endotracheal intubation (3.5-internal-diameter tube) and continuous positive airway pressure (CPAP) treatment (mode: SIMV+capacity control, parameters: oxygen concentration 31%, PEEP 4 cm H2O, respiratory rate 30/min, tidal volume 18 ml). A chest X-ray revealed her left lung collapse and diaphragmatic hernia (Figure 1B). The hospital urgently held a meeting involving neonatologists, anesthesiologists, and surgeons to formulate a reasonable treatment plan jointly. Finally, the CDH repair was planned under general anesthesia. After completing the relevant examinations, the child immediately was transferred to the operating room for emergency CDH repair after sufficient preoperative preparation. The combined diagnoses were metabolic acidosis, neonatal pneumonia with respiratory failure, pulmonary dysplasia, congenital heart disease, patent foramen ovale (2 mm), patent ductus arteriosus (2 mm), and pulmonary hypertension (78 mmHg).

The patient entered the operating room with ventilator-assisted breathing. Heart rate (HR) was 162 bpm, pulse oxygen saturation (SPO2) was 90%, and respiratory rate (RR) was 55/min. Extensive diaphragmatic hernia caused the newborn's left lung to atrophy almost completely, leading to severe hypoxia and acidosis. High thoracic and abdominal pressure further increased respiratory depression. Increased thoracic pressure led to decreased cardiac output. In this case, the pulmonary artery pressure of the infant was high, preoperative cardiac ultrasound detected atrial horizontal bidirectional shunt, a large amount of venous blood entered the systemic circulation without pulmonary oxygenation, the respiratory and circulatory function was on the verge of collapse.

The anesthesia team realized that if routine anesthesia induction was performed, the patient might have further increased airway pressure due to the use of muscle relaxants

Received December 8, 2021; received in revised form February 17, 2022; accepted February 27, 2022.

Correspondence: Zhu Zhaoqiong, Department of Anesthesiology, Affiliated Hospital of Zunyi Medical University, Zunyi, Guizhou 563000, China, Telephone 13035529980 (e-mail: zzbhaofan@sina.com).

and positive pressure ventilation, thoracoscopic pneumoperitoneum would further increase the pressure of the thoracic cavity and even had the risk of cardiac arrest. Even if propofol was used to retain spontaneous breathing induction as recommended by many previous reports, it might also lead to myocardial inhibition. The prevention of sudden cardiac arrest during anesthesia induction was the critical problem in this case.

The child was carefully moved from the incubator to the operating table, and the anesthesia machine related to the child's endotracheal tube properly. After monitoring the vital signs, the venous channel on the right upper limb was established. No preoperative medication was used. Slow intravenous infusion of fentanyl 2 μg/kg to keep spontaneous breathing. A hypnotic state was induced using i.v. S-ketamine 1 mg/kg followed by propofol administration 0.5 mg/kg. The parameters of the anesthesia machine were set for mechanical ventilation: tidal volume 18 ml/kg, RR 30/min.

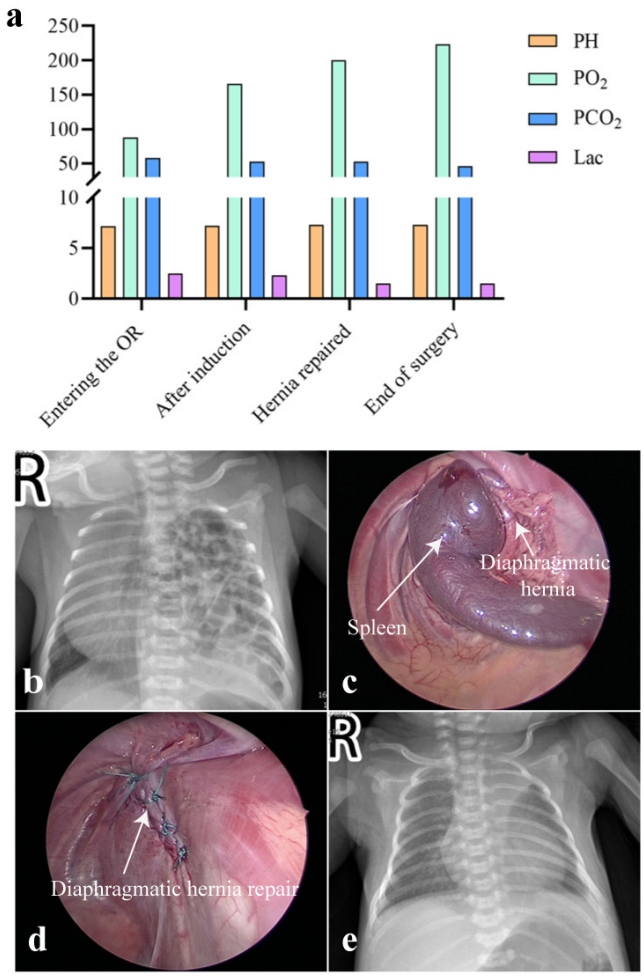

Figure 1. Description of perioperative events. (a) The trend of blood gas analysis at different time points. (b and e) Comparison of preoperative and postoperative imaging data. (c and d) Visual fields during the laparoscopic operation.

S-ketamine 0.5 mg/kg/h and remifentanil 0.1 μg/kg/min were injected intravenously to maintain anesthesia. There was no severe fluctuation after anesthesia induction. Vital signs after anesthesia induction: HR 139/min, BP 80/43, SPO2 96%. Ultrasound-guided arterial blood pressure (ABP) and central venous pressure (CVP) monitoring were established quickly after induction. Blood gas analysis was checked immediately before operation (Figure 1A).

The child was placed in the right decubitus position; the surgeon placed the puncture sheath through her left thoracic cavity. The operating space was maintained with continuous carbon dioxide (CO2) insufflation with pressure at 4 mmHg. Although no one-lung ventilation was performed, the left lung collapsed well, and the operation field was clear (Figure 1C). After the hernia contents were returned (Figure 1D), the muscle relaxants were applied to relieve respiratory muscle fatigue. The HR was between 120 ~140 bpm, SpO2 was between 92% ~ 95%, the average ABP was maintained at 50 ~ 60 mmHg, and body temperature was about 36.5°C. Acidosis and electrolyte disorder was positively corrected according to close monitoring of blood gas analysis results.

After the surgical repair, the lungs correctly were expanded, and the hypoxia of the child immediately was relieved. The total duration of the operation was 75 minutes. The child returned to neonatal pediatrics with an endotracheal tube for further treatment. The endotracheal tube was removed two days after the operation, and the child recovered well and was discharged the second week after the operation (Figure 1E).

Chest X-ray showed no recurrence of CDH one month after surgery. Her neurodevelopmental assessment was normal for age with good growth at half a year follow up. Cardiac ultrasound showed that the foramen ovale and pulmonary artery duct were closed, and the measured value of pulmonary artery pressure was normal.

Ethics: Informed consent was obtained from the patient's legal guardian, and the Ethics Committee approved the disclosure of this clinical case at Zunyi Medical University. This case strictly adheres to the ethical standards of the Declaration of Helsinki and the International Ethical Guidelines for Human Biomedical Research.

DISCUSSION

This case reported the anesthesia and surgical treatment of a critically ill newborn. There exists no unified standard treatment guideline for neonatal CDH yet. Thus, perioperative anesthesia management is very challenging [Qin 2019]. If there were no complete self-employed anesthesia plans, it would jeopardize the patient.

Minimally invasive surgery (MIS) has the advantage of minor trauma, less bleeding, and rapid recovery. However, concerns arise due to physiological stress associated with MIS and acidosis, due to retained CO2 in infants. Constant infusion of CO2 at a certain pressure to maintain the operating space can lead to serious hemodynamic changes [Balasubramanian 2019]. These complications often are tolerable in adult patients, but they will be life-threatening to newborns.

All the above considerations prompt strict requirements for anesthesiology management. It is found that the change of PetCO2 lags behind that of arterial CO2 pressure (PaCO2) during thoracoscopic surgeries [Aihole 2018]. Therefore, with the extension of the operation time, respiratory management should be adjusted in time in combination with blood gas analysis results. If there is an intolerable increase in PaCO2, consider requesting the discontinue insufflation of CO2 or conversion to open surgery.

It is worth noting that sevoflurane is an inhaled anesthetic commonly used in the anesthesia of critically ill children in recent years. It enables precise breathing control or retained spontaneous respiration, with no need for muscle relaxants. However, sevoflurane was completely ineffective in the anesthesia management of this case. Because of the heart disease and pulmonary hypertension in this patient, there was very little effective gas for blood gas exchange, sevoflurane could not play an anesthetic role in this case. After discussion, we chose S-ketamine for anesthesia, propofol, and opioids would further inhibit respiratory function and cardiac output. Ketamine is a non-competitive blocker of glutamate N-methyl-D-aspartate (NMDA) receptors. It was shown to be clinically superior to the racemic mixture of ketamine regarding anesthetic potency and hemodynamic stability [Pees 2003]. It has the pharmacological characteristics to increase systemic circulation resistance, prevent two-way shunt, and maintain spontaneous breathing. The combined induction of minimal-dose fentanyl, propofol, and S-ketamine in this case not only reduced the myocardial inhibition of general anesthetics through the sympathetic excitation of S-ketamine, but also retained spontaneous breathing and avoided cardiovascular accidents.

In addition, before the hernia contents are returned, muscle relaxants should be banned to avoid the increase of diaphragmatic hernia contents caused by diaphragmatic relaxation. During the induction process, try to prevent high-pressure assisted breathing. After the hernia content is returned, the muscle relaxant is given, and the ventilation should be appropriately increased. Still, the pressure should be gradually increased to prevent the rapid expansion of collapsed lungs from causing atelectasis. Theoretically, single-flight ventilation is conducive to a surgical operation. Due to neonatal anatomy and physiological reasons, it has not been widely carried out in China. We presently adopt the scheme of low tidal volume and fast frequency. Our experience is that newborns have better tolerance to hypoxia than older children, especially for preterm infants [Testini 2017]. To avoid oxidative stress injury induced by pure oxygen to newborns, pure oxygen should not be inhaled during anesthesia induction and maintenance stages. Adjust the fraction of inspiration O2 (FiO2) and maintain the SpO2 at about 90% and no less than 85%. Currently, published guidelines recommend preferential lower airway pressures while allowing for permissive hypercapnia [Yang 2021; Latham 2019]. These systematic reviews support gentle ventilation strategies to achieve improvements in survival while minimizing iatrogenic lung injury.

In this case report, antenatal scans were performed in a local hospital, no pictures were available to review, and the diagnosis of CDH was made postnatally. This largely depends on the expertise of the obstetrician, as this condition is not antenatally diagnosed in all cases and accuracy varies among different centers. Several articles discussed the need for vasodilator and extracorporeal membrane oxygenation (ECMO) to resuscitation severe CDH patients before operation [Szavay 2012; Kays 2017]. The ECMO team was on standby before the operation, but this case discussion emphasizes the adaptability of anesthesiologists in extreme cases. Our experience is that anesthesiologists must be familiar with all neonatal anesthesia techniques. Although the patient's condition was critical, she was close to full-term. Her clinical symptoms mainly came from CDH and had surgical indications. Through cooperation and appropriate perioperative management, most critically ill children have good tolerance to general anesthesia, and the related symptoms will recover slowly after operation without traumatic external interventions. Furthermore, with the maturity of technology, some surgical contraindications considered in the early stage need to be recognized again. Some early contraindications of endoscopic surgery for a diaphragmatic hernia in children deserve to be reconsidered.

There still are significant challenges in anesthesia for minimally invasive diaphragmatic hernia surgery in newborns. It is essential to formulate individualized anesthetic management plans for different children and choose the most appropriate anesthetics to ensure an excellent anesthetic effect. The positive role of multidisciplinary cooperation in ensuring the safety of children also should be highlighted. Continuous experience summary will optimize the anesthesia management of such operations in the future.

REFERENCES

Aihole JS, Gowdra A, Javaregowda D, Jadhav V, Babu MN, Sahadev R. 2018. A clinical study on congenital diaphragmatic hernia in neonates: our institutional experience. J Indian Assoc Pediatr Surg. 23(3):131-139.

Balasubramanian B, Malde AD, Kulkarni SB. 2019. A non-randomized controlled study of total intravenous anesthesia regimens for magnetic resonance imaging studies in children. J Anaesthesiol Clin Pharmacol. 35(3):379-385.

Choudhry M, Rusu S, Brooks P, Ogundipe E, Chuang SL. 2021. Thoracoscopic repair of congenital diaphragmatic hernia in preterm neonate at 1 kilogram. European J Pediatr Surg Rep. 9:13-16.

Goonasekera C, Ali K, Hickey A, Sasidharan L, Mathew M, Davenport M, et al. 2016. Mortality following congenital diaphragmatic hernia repair: the role of anesthesia. Paediatr Aneaesth. 26(12):1197-1201.

Kays DW. 2017. ECMO in CDH: Is there a role? Seminars in pediatric surgery. 26(3):166–170.

Latham GJ, Yung D. 2019. Current understanding and perioperative management of pediatric pulmonary hypertension. Paediatr Aneaesth. 29(5):441-456.

Pees C, Haas NA, Ewert P, Berger F, Lange PE. 2003. Comparison of analgesic/sedative effect of racemic ketamine and S(+)-ketamine during cardiac catheterization in newborns and children. Pediatr Cardiol. 24(5):424-429.

Qin J, Ren Y, Ma D. 2019. A comparative study of thoracoscopic and

open surgery of congenital diaphragmatic hernia in neonates. Journal of Cardiothoracic Surgery. 14(1):118.

Szavay PO, Obermayr F, Maas C, Luenig H, Blumenstock G, Fuchs J. 2012. Perioperative outcome of patients with congenital diaphragmatic hernia undergoing open versus minimally invasive surgery. JLaparoendosc Adv Surg Tech A. 22(03):285-289.

Testini M, Girardi A, Isernia RM, De Palma A, Catalano G, Pezzolla A, et al. 2017. Emergency surgery due to diaphragmatic hernia: case series and review. World J Emerg Surg. 12:23.

Yang MJ, Russell KW, Yoder BA, Fenton SJ. 2021. Congenital diaphragmatic hernia: a narrative review of controversies in neonatal management. Transl Pediatr. 10(5):1432-1447.