Anesthesia Management in Laparoscopic Congenital Diaphragmatic Hernia

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Abstract

Congenital diaphragmatic hernia / hiatal hernia (Congenital Diaphragmatic Hernia / CDH) alters normal cardiopulmonary physiology in neonates or pediatric patients due to pressure from the abdomen into the thoracic cavity. The open surgical and the laparoscopic approaches pose challenges for the anesthesiologist and the team because of the complications of CDH and the surgery itself. We present a case of successful anesthetic management of a diaphragmatic hernia in a 2-year-old child undergoing laparoscopic surgery.

Keywords: Congenital Diaphragmatic Hernia, Pediatric, Anesthesia Management, Laparoscopy

1. Introduction

Congenital diaphragmatic hernia (CDH) is a rare congenital condition in which incomplete diaphragm closure causes herniation of the abdominal viscera into the thoracic cavity. Increased intrapulmonary pressure affects the developing cardiopulmonary system. Anesthesia management, in this case, requires an in-depth understanding of the changes in cardiopulmonary function in CDH and the burden of physiologic changes caused by laparoscopy to ensure patient safety and accelerate recovery..

2. Case Presentation

A 2-year-old male patient was weighing 10 kg presented with asymptomatic CDH/hiatal hernia. The patient was diagnosed with a diaphragmatic hernia by accident during a chest X-ray screening after the patient was diagnosed with COVID-19 infection (Figure 1). There were no symptoms complained of by the parents, and the patient could carry out normal daily activities. The patient was confirmed to have a diaphragmatic hernia after a CT scan showed herniation of the stomach and a portion of the colon in the right hemithorax in the posteroventral part of the diaphragm with a defect diameter of about 1.8 cm (Figure 2). This is also supported by bowel sounds in the right hemithorax on physical examination. There was no respiratory distress or abdominal distention, and the patient was hemodynamically stable. Other physical examinations were within normal limits. The echocardiographic study showed no cardiomegaly, left ventricular hypoplasia, congenital heart disease, or signs of pulmonary hypertension. The results of laboratory tests showed the normal range.

During the perioperative period, the patient was premedicated with ketamine 5 mg intravenously, midazolam 1 mg intravenously, and the H2 blocker ranitidine 10 mg intravenously for aspiration prevention

in the operating room. Standard pediatric monitoring such as 5-lead ECG, Non-invasive Blood Pressure (NIBP), pulse oximetry, temperature monitoring, precordial stethoscope, and ETCO2 was used for intraoperative monitoring. Monitoring of preductal and postductal pulse oximetry, arterialization, and central venous catheter (CVC) was not performed because PDA was not diagnosed, and hemodynamics was still stable.

Preoxygenation was performed using 100% oxygen with minimal positive pressure ventilation to avoid gastric distention. Induction using sevoflurane 8 volume %, analgesia with fentanyl two mcg per kg/kg intravenously, and the non-depolarizing muscle relaxant atracurium 0.6 mg/kg body weight to facilitate intubation. Endotracheal intubation was successfully performed in the first trial, followed by caudal analgesia with 0.125% bupivacaine at a dose of 1.25 ml/kg BW target height in the mid thorax. Anesthesia maintenance was performed using sevoflurane 2.5 to 3 Vol %; O2 50%; compress water 50%. The patient was then positioned in reverse Trendelenburg 30 degrees given CO2 pressure of 10-12 mmHg intra-abdominal 1. Pressure control mode was used, and pressure was adjusted during laparoscopy based on intra-abdominal pressure, tidal volume achieved, and end-tidal CO2 (ETCO2) value. During CO2 insufflation and the reverse Trendelenburg position, the respiratory pressure is increased to 16-17 mmHg, and the respiratory rate is increased to 22-24 breaths/min to maintain the ETCO2 between 30-38 mmHg. Laparoscopy lasts 2 hours; oxygen saturation and hemodynamics were stable during laparoscopy. It was found that the diaphragm was intact without perforation and had difficulty in releasing the stomach and intestines that were trapped in the hernia, so it was continued with open surgery by the surgeon. During open surgery, there were several episodes of tachycardia and hypotension because the retractors were placed near the mediastinum and the pressure on the heart affected hemodynamics significantly. We asked the surgeon to stop the manipulation, and the hemodynamics quickly improved. In open surgery, intra-abdominal pressure is no longer a significant problem. Still, we must be aware of the manipulation of the retractors that can compress the mediastinum or diaphragm, which affects hemodynamics.

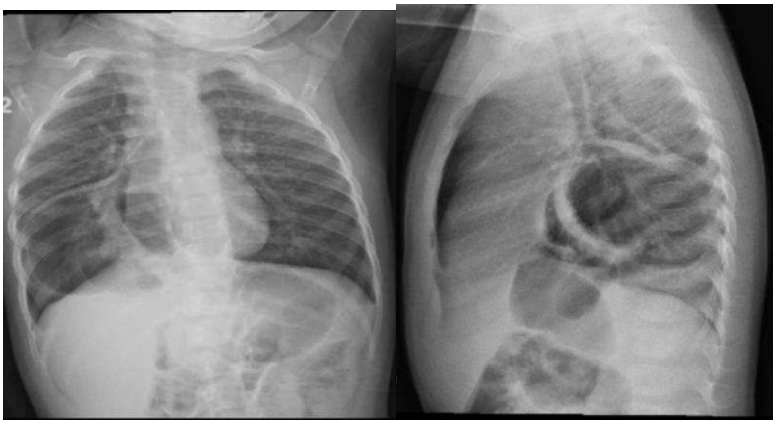

Figure 1. Thorax X-ray

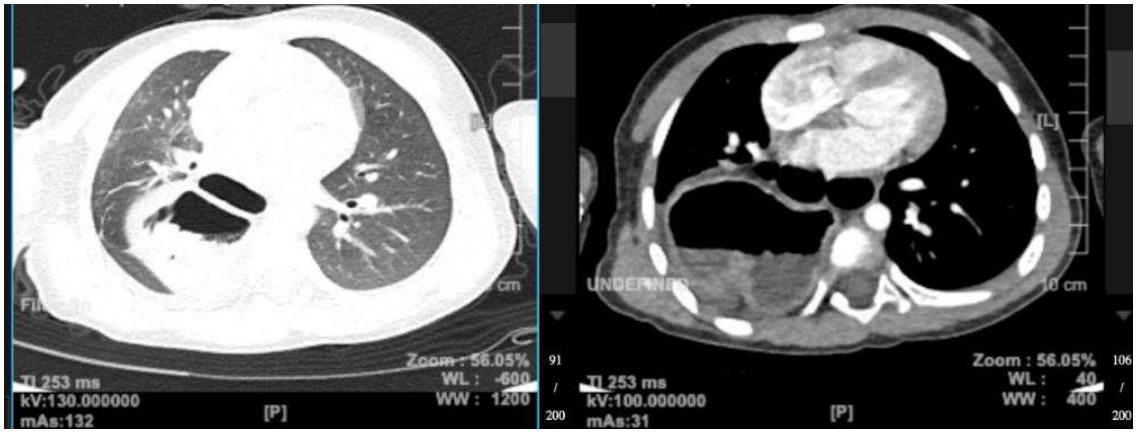

Figure 2. Abdominal CT Scan

No other complications were observed during the intraoperative period. Surgery was completed after 5 hours and decurarized with atropine 0.03 mg kg-1 and neostigmine 0.06 mg kg-1. The patient was extubated after optimal spontaneous ventilation, admitted to the Pediatric Intensive Care Unit, and discharged after three days without complications

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3. Discussion

The primary pathology in congenital diaphragmatic hernia is the effect of compression of the abdominal contents into the chest cavity. Underdeveloped lungs or pulmonary hypoplasia lead to poor gas exchange and pulmonary hypertension due to hypertrophy and remodeling of the pulmonary vasculature. This high pressure in the pulmonary veins causes right ventricular hypertrophy. Poor gas exchange eventually leads to several conditions, namely: increased arterial CO2 levels, and prolonged acidotic hypoxemia, thereby increasing pulmonary vascular reactivity and exacerbating pulmonary hypertension.(Pierro and Thébaud, 2014; Shah, Sharma and Bhandarkar, 2015; Kozanhan et al., 2016). The severity of pulmonary hypertension is related to the severity of CDH, which determines postoperative morbidity and mortality; where in this case, no pulmonary hypertension was found. Mortality of live births with CDH reaches 25% to 30%, exacerbated mainly by pulmonary hypertension (Harting, 2017).

The effects of compression in the mediastinum can also affect cardiac anatomy and cause left ventricular hypoplasia and right ventricular hypertrophy. Poor left ventricular function by decreased volume and pressure in the right ventricle and hypertrophy causes significant right (R) to the left (L) shunting via PFO (Patent Foramen Ovale) or PDA (Patent Ductus Arteriosus), leading to severe hypoxemia. To test for right-to-left shunting in PDA abnormalities, dual pulse oximetry at the preductal site (right hand) and the post-ductal site (both legs) can be used.(Shah, Sharma and Bhandarkar, 2015; Kozanhan et al., 2016).

Other congenital abnormalities accompanying CDH must be enforced because they significantly affect anesthesia management. A complete preoperative examination is essential to rule out other genetic abnormalities. History, thorough physical examination, laboratory investigations, standard radiology, and echocardiography are critical in this case. (Table 1).

Table 1. Summary of Perioperative Anesthesia Considerations in Laparoscopic Diaphragmatic Hernia

Preoperative	Intraoperative	Postoperative
• Complete medical history • Sign of congenital abnormality (VACTREL) • Respiratory and airway problems (as clubbing finger, central cyanosis, respiratory distress • Standart lab work and radiology. Echocardiography is essential in ruling out cardiac problem • Adequate fasting time and abdominal decompression (nasogastric tube if needed) • **Preoprative target: Optimalazing patient's condition, Knowing patient's hemodynamic baseline**	• IV line access, make sure the patient is isovolemic • Standart Monitoring: Pulse oxymetry (preductal and post ductal), ECG 5 leads, NIBP, Precordial stetoschope, ETCO2, temperature probe • Invasive hemodynamic monitoring if needed (CVC, Arterial line) • Little or no positive pressure preoxygenation • Nasogastric tube • No or small dose of muscle relaxant • No Nictric oxide unless there's sign of pulmonary hypertension • **Intraoperative target: Stable hemodynamic, Permissive hypercapnia, Adequate analgetic (consider regional block)Adequate anesthesia depth**	• **Postoperative target: Full recovery from anesthesia and muscle relaxant, Adequate pain management (consider regional block post operative), smoothe extubation, stable hemodynamic** • Blood gas analysis postoperative • Thorax x-ray Postoperative • Pediatric ICU for postoperative care and monitoring • Monitored of bowel function and early oral feeding

Our patient had a 1.8-diameter CDH defect in the posterior mediastinum with an intact diaphragm. Most of the stomach and large intestine were trapped in the defect, but no strangulation bowel was found. This entire diaphragm may cause the patient's still having normal lung development and no complaints even on activity. Intrathoracic pressure can be maintained and only slightly increased due to entrapped colon and stomach. Echocardiography shows no signs of underdeveloped or hypertrophied ventricles, congenital disabilities, or pulmonary hypertension.

Surgical management of CDH repair can be performed by open surgery with a transabdominal or transthoracic or laparoscopic approach, both of which have their respective advantages and risks. The

laparoscopic approach provides the benefits of minimal postoperative trauma and pain, shorter postoperative bowel function recovery time, early postoperative mobilization, and shorter hospital stay.(Kozanhan et al., 2016; Pelizzo et al., 2017)A major challenge for the anesthesiologist and team is the Durante and postoperative complications of laparoscopic surgery.

The cardiopulmonary complications underlying CDH are likely exacerbated by increased intra-abdominal pressure and pneumoperitoneum during CO2 insufflation. Pneumoperitoneum causes an increase in thoracic pressure that requires adjustment of the peak pressure to achieve minimal tidal volume and maintain ETCO2 levels at 30-35 mmHg. Changes in lung physiology during laparoscopy include decreased lung compliance, increased peak pressure, and reduced functional residual capacity (FRC). In neonates with a closing volume more incredible than the FRC, this can lead to small airway collapse(McHoney et al., 2003; Kozanhan et al., 2016). Neonates and pediatric patients have a greater peritoneal surface-to-weight ratio, and a thinner peritoneal layer allows for faster CO2 absorption compared to adults. This allows for more CO2 absorption. Hypercapnia can increase heart rate, blood pressure, and intracranial pressure and cause arrhythmias. CO2 that diffuses into the chest cavity can also cause subcutaneous emphysema, pneumothorax, pneumomediastinum, and pneumopericardium. 3 Laparoscopic action also causes mechanical effects that cause pathological conditions such as stretching of the peritoneum, causing vagal reflexes, and increasing intra-abdominal pressure so that it interferes with hemodynamic function.(Taneja, 2009; Chatterjee, Ing and Gien, 2020). In this patient, during the duration of surgery, there was no significant increase in CO2 as shown on the ETCO2 monitor, only a maximum rise in 45mmHg immediately after insufflation and then returning to a value of 35-40 mmHg after efforts to increase respiratory rate and inspiratory pressure.

In the perioperative period, it is essential to ensure that there are no pathological conditions to cardiorespiratory function such as signs of hypoxemia and respiratory distress due to changes in the anatomy of the respiratory organs and R to L shunt due to changes in cardiac anatomy caused by CDH. This patient had no signs of impaired cardiorespiratory function from the history, physical examination, and investigations. The risk of aspiration pneumonia occurs in most cases of CDH, so aspiration prophylactic premedication such as H2 blockers, proton pump inhibitors, and antiemetics (metoclopramide or ondansetron is essential 3-5). During preoxygenation, positive pressure ventilation can be used at minimal pressure or should be contraindicated in patients with high abdominal pressure. In the case of CDH, induction of anesthesia can use intravenous and inhaled induction agents.

In contrast, using muscle relaxants as an intubation facility is still controversial, especially in CBD with pulmonary hypoplasia. The evidence does not show particular benefits and can even increase atelectasis. This patient was given a muscle relaxant as an intubation facility because there was no pulmonary hypoplasia. The use of N2O is relatively avoided in laparoscopy but should be considered in pulmonary hypertension with normal cardiac function.

After surgery, close monitoring was carried out in the Intensive Care Unit (ICU) on physical examination and support (blood gas analysis, chest X-ray) did not show signs of hypercapnia, pneumothorax, pneumoperitoneum, and pneumomediastinum. Postoperative analgesia can be performed multimodally using opioids, NSAIDs, paracetamol, or regional blocks3-5. In this case, postoperative analgesia was given in combination with the opioid fentanyl 0.25 mcg per kg body weight intravenously with the NSAID ibuprofen 50 mg every 8 hours

4. Conclusions

Anesthesia management in pediatric patients with congenital diaphragmatic hernia with a laparoscopic approach is a formidable challenge for the anesthesiologist and the team. An in-depth understanding of pediatric physiology, changes in cardiopulmonary function in CDH, and laparoscopic anesthetic techniques are essential to ensure patient safety and accelerate recovery

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Conflicts of Interest: none

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